BS EN 61207-7:2013

Incorporating corrigendum June 2015

BSI Standards Publication

Expression of performance of gas analyzers

Part 7: Tuneable semiconductor laser gas analyzers

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National foreword

This British Standard is the UK implementation of EN 61207-7:2013. It is identical to IEC 61207-7:2013, incorporating corrigendum June 2015.

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 subcommittee can be obtained on request to its secretary.

Published by BSI Standards Limited 2015

ISBN 978 0 580 90946 7
ICS 19.040; 71.040.40

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 31 January 2014.

Amendments/corrigenda issued since publication

Date	Text affected
31 July 2015	Implementation of IEC corrigendum June 2015. Figure B.1 updated

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61207-7

December 2013

ICS 19.040; 71.040.40

English version

Expression of performance of gas analyzers - Part 7: Tuneable semiconductor laser gas analyzers

(IEC 61207-7:2013)

Expression des performances
des analyseurs de gaz -
Partie 7: Analyseurs de gaz laser à semi-conducteurs accordables
(CEI 61207-7:2013)

Angabe zum Betriebsverhalten
von Gasanalysatoren -
Teil 7: Gasanalysatoren mit abstimmbaren Halbleiterlasern
(IEC 61207-7:2013)

This European Standard was approved by CENELEC on 2013-10-30. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre 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

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

Ref. No. EN 61207-7:2013 E

Foreword

The text of document 65B/876/FDIS, future edition 1 of IEC 61207-7, prepared by SC 65B "Measurement and control devices" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61207-7:2013.

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)	2014-07-30
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-10-30

This Standard is to be used in conjunction with EN 61207-1:2010.

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

Endorsement notice

The text of the International Standard IEC 61207-7:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

ISO 9001	NOTE	Harmonized as EN ISO 9001.

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 60654-1	1993	Industrial-process measurement and control equipment - Operating conditions - Part 1: Climatic conditions	EN 60654-1	1993
IEC 60654-2 + A1	1979 1992	Operating conditions for industrial-process measurement and control equipment - Part 2: Power	EN 60654-2 [1]	1997
IEC 60654-3	1983	Operating conditions for industrial-process measurement and control equipment - Part 3: Mechanical influences	EN 60654-3	1997
IEC 60825-1	2007	Safety of laser products - Part 1: Equipment classification and requirements	EN 60825-1	2007
IEC 61207-1	2010	Expression of performance of gas analyzers - Part 1: General	EN 61207-1	2010

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1) EN 60654-2 includes A1 to IEC 60654-2.

CONTENTS

INTRODUCTION

This part of IEC 61207 includes the terminology, definitions, statements and tests that are specific to tuneable semiconductor laser gas analyzers, which utilize tuneable semiconductor laser absorption spectroscopy (TSLAS).

Tuneable semiconductor laser gas analyzers utilize tuneable semiconductor lasers (e.g. diode lasers, quantum cascade lasers, interband cascade lasers) as light sources, whose wavelength covers ultraviolet, visible and infrared part of the electromagnetic spectrum, to detect the absorption spectra and thus determine the concentration of gases to be analyzed. These analyzers may employ different TSLAS techniques such as direct absorption spectroscopy, frequency modulation spectroscopy (FMS), wavelength modulation spectroscopy (WMS), etc. Multi-pass absorption spectroscopy, photoacoustic spectroscopy (PAS), and cavity-enhanced absorption spectroscopy (CEAS) such as cavity-ringdown spectroscopy (CRDS) are also used to take advantage of their high detection sensitivity.

Tuneable semiconductor laser gas analyzers are usually used to measure concentration of small molecule gases, such as oxygen, carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, hydrogen fluoride, hydrogen chloride, nitrogen dioxide, water vapour etc.

There are two main types of tuneable semiconductor laser gas analyzers: extractive and in situ analyzers. The extractive analyzers measure the sample gas withdrawn from a process or air by a sample handling system. The in situ analyzers measure the gas in its original place, including across-duct, probe and open-path types. Across-duct analyzers either have a laser source and a detector mounted on opposite sides of a duct, or both the laser and the detector are mounted on the same side and a retroreflector on the opposite side of a duct. Probe analyzers comprise a probe mounted into the duct, and the measured gas either passes through or diffuses into the measuring optical path inside the probe. And open-path analyzers measure the gas in an open environment with a hardware approach similar to across duct analyzers (source and detector on opposite sides of the open area or a retroreflector on one side and the source and detector on the opposite side), except the sample is in an open path and not contained in a duct.

NOTE 1 Traditionally, only diode lasers were employed, and thus tuneable diode laser gas analyzers and tuneable diode laser absorption spectroscopy (TDLAS) are widely used terms. However, with the development of laser technology, many other types of semiconductor lasers, such as quantum cascade lasers (QCLs) and interband cascade lasers (ICLs) have been developed and employed in laser gas analyzers. Therefore, the term of semiconductor laser rather than diode laser is used in this standard to reflect this technology advancement.

NOTE 2 Though tuneable semiconductor laser photoacoustic spectroscopy (PAS) is in principle different from absorption spectroscopy typically used in tuneable semiconductor laser gas analyzers, the hardware and data reduction software are almost the same for analyzers utilizing these two spectroscopy technologies, and thus PAS is considered a variant of absorption spectroscopy and this standard also applies to the analyzers based on PAS.

EXPRESSION OF PERFORMANCE OF GAS ANALYZERS –

Part 7: Tuneable semiconductor laser gas analyzers

1 Scope

This part of IEC 61207 applies to all aspects of analyzers utilizing TSLAS for the concentration measurement of one or more gas components in a gaseous mixture or vapour.

It applies to analyzers utilizing tuneable semiconductor lasers as sources and utilizing absorption spectroscopy, such as direct absorption, FMS, WMS, multi-pass absorption spectroscopy, CRDS, ICOS, PAS and CEAS techniques, etc.

It applies both to in situ or extractive type analyzers. This standard includes the following, it

- specifies the terms and definitions related to the functional performance of gas analyzers, utilizing tuneable semiconductor laser gas absorption spectroscopy, for the continuous measurement of gas or vapour concentration in a source gas,
- unifies methods used in making and verifying statements on the functional performance of this type of analyzers,
- specifies the type of tests to be performed to determine the functional performance and how to carry out these tests,
- provides basic documents to support the application of the standards of quality assurance with in 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 60654-1:1993, *Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic conditions*

IEC 60654-2:1979, *Operating conditions for industrial-process measurement and control equipment – Part 2: Power*
Amendment 1:1992

IEC 60654-3:1983, *Operating conditions for industrial-process measurement and control equipment – Part 3: Mechanical influences*

IEC 60825-1:2007, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61207-1:2010, *Expression of performance of gas analyzers – Part 1: General*

3 Terms and definitions

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

3.1
semiconductor laser
solid-state laser, in which the semiconductor material is used as active media

3.2
diode laser
semiconductor laser which is formed from a p-n junction and powered by injected electric current

3.3
quantum cascade laser
semiconductor laser whose laser emission is achieved through the use of intersubband transitions in a repeated stack of semiconductor multiple quantum structure, and typically emits in the mid- to far-infrared portion of the electromagnetic spectrum

3.4
interband cascade laser
semiconductor laser whose laser emission is achieved through the use of interband transitions between electrons and holes in a repeated stack of semiconductor multiple quantum structure, but, instead of losing an electron to the valence band, the valence electron can tunnel into the conduction band of the next quantum structure, and this process can be repeated throughout the multiple quantum structure

3.5
extractive analyzer
analyzer which receives and analyzes a continuous stream of gas withdrawn from a process by a sample handling system

3.6
in situ analyzer
analyzer which measures the gas in its original place, including across-duct, probe and open-path types

3.7
tuneable semiconductor laser absorption spectroscopy
TSLAS
spectroscopy which utilizes a tuneable semiconductor laser as radiation source, tunes the emission wavelength of the laser over the characteristic absorption lines of measured species in the laser beam path, detects the reduction of the measured signal intensity, and then determines the gas concentration

3.8
tuneable semiconductor laser gas analyzer
gas analyzer which utilizes TSLAS to measure the concentration of one or more gas components in a gaseous mixture or vapour

3.9
wavelength modulation spectroscopy
laser gas absorption spectroscopy, in which the wavelength of the laser beam is continuously modulated across the absorption line and the signal is detected at a harmonic of the modulation frequency

Note 1 to entry: Wavelength modulation spectroscopy utilizes a modulation frequency which is less than the half-width frequency of the transition lineshape.

3.10
frequency modulation spectroscopy

spectroscopy that uses a modulation frequency larger than the half-width frequency of the transition lineshape which results in a pair of sidebands separated from the carrier by the modulation frequency

Note 1 to entry: An alteration of any of the sidebands by absorption causes an unbalance and therefore a net signal which can be detected by a high speed photodetector.

3.11
cavity enhanced absorption spectroscopy

spectroscopy which utilizes the resonance of laser beam in high-finesse optical cavity to prolong the effective path lengths

3.12
photoacoustic spectroscopy

spectroscopy which is based on the photoacoustic effect

Note 1 to entry: The acoustic effect is the energy from the laser beam transformed into kinetic energy of the absorbing gas molecules. This results in local heating and thus a pressure wave or sound. By measuring the sound intensity, the gas concentration can be determined.

3.13
multi-pass absorption spectroscopy

absorption spectroscopy utilizing a multi-pass gas cell, in which the reflected laser beam passes through the gas multi-times to increase optical path length

3.14
transmittance

ratio of incident light energy transmitted to the total light energy incident on a given sample

3.15
transmittance influence uncertainty

maximum difference between the indicated values of gas concentration when transmittance assumes any value larger than the rated minimum transmittance, while all other values are at reference conditions

EXAMPLE Transmittance is reduced by dust, liquid droplets, and other particles in the measured gas and the pollution of optical windows.

3.16
purge

method using zero gas to blow parts of the analyzer during measurement or calibration to prevent the optical components from staining or being coated, and to implement positive pressure explosion protection, or to avoid interference from gases outside measured path

3.17
purged optical path length

length of optical path filled with purge gas

3.18
gas temperature

temperature of measured gases

EXAMPLE Temperature of gas in the duct for across-duct analyzers, temperature of gas in the probe cavity for probe analyzers, ambient gas temperature in the open environment for open-path analyzers, gas temperature in the gas cell for extractive analyzers.

3.19
gas pressure

pressure of measured gases

EXAMPLE The pressure in duct for across-duct and probe analyzers, ambient pressure of the open environment for open-path analyzers, and the pressure in gas cell for extractive analyzers.

3.20
gas temperature influence uncertainty

maximum difference between the indicated values of gas concentration when the temperature assumes any value within the rated range of gas temperature, all others being at reference conditions

3.21
gas temperature influence uncertainty for calibration

maximum difference between the indicated values of gas concentration when the temperature assumes any value within the rated range of calibration gas temperature, all others being at reference conditions

3.22
gas pressure influence uncertainty

maximum difference between the indicated values of gas concentration when the pressure assumes any value within the rated range of gas pressure, all others being at reference conditions

3.23
gas pressure influence uncertainty for calibration

maximum difference between the indicated values of gas concentration when the pressure assumes any value within the rated range of calibration gas pressure, all others being at reference conditions

3.24
laser safety

safety design for use and implementation of lasers to minimise the risk of laser accidents, especially those involving eye injuries

3.25
optical interference noise

interference fringes generated through multiple beam interferences between optical surfaces within the coherent light source and the detector

Note 1 to entry: Interference fringes cause oscillation of the photocurrent during wavelength scanning. This oscillation results in noise added to the absorption signal.

3.26
interfering components

components which interfere with the measurement of target species

Note 1 to entry: These interfering components include not only optically absorbing species by the fact that the absorbance spectrum overlaps to the target species, but also non-optically absorbing species by line broadening of the target species. (this can make stating/determining the measurement accuracy difficult).

Note 2 to entry: Namely, shape of optical absorbance spectrum of target species to be measured can be changed itself significantly by change of background gas composition.

4 Procedure for specification

4.1 General

The procedures for specification are detailed in IEC 61207-1. This covers:

- operation and storage requirements;
- specification of ranges of measurement and output signals;
- limits of uncertainties;
- recommended reference values and rated ranges of influence quantities (see IEC 60654-1, IEC 60654-2, IEC 60654-3).

In this standard, additional operation and service requirements are given. Additional terms for specification of performance and important aspects of performance relevant to tuneable semiconductor laser gas analyzers are also detailed.

4.2 In situ analyzers

4.2.1 Additional operation and maintenance requirements

4.2.1.1 Facilities and requirements for purge

The quality of purge gas such as dust and oil load, concentration limit of measured gas component in the purge gas, and rated range of purge gas pressure and flow rate shall be stated.

4.2.1.2 Facilities and methods for calibration or electronic and optical integrity checking

The rated range of temperature, pressure and flow rate of calibration gas shall be stated.

The gas components and their corresponding concentration levels in calibration gas shall be stated.

Facilities and procedures for optical aligning shall be stated.

4.2.1.3 Facilities and requirements for automatic compensation for gas temperature or pressure variations

Specifications of required temperature or pressure sensors shall be stated.

4.2.1.4 Facilities and requirements for essential maintenance

Maintenance methods, facilities and the time intervals for maintenance shall be stated.

4.2.2 Additional terms related to the specification of performance

4.2.2.1 Rated minimum transmittance, above which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.2.2 Rated range of optical path length, which is required to ensure sufficient gas absorption and transmittance.

4.2.2.3 Rated range of gas temperature, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.2.4 Rated range of gas pressure, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.2.5 Rated range of calibration gas temperature, within which the uncertainty of calibration is below the specified uncertainty limit, shall be stated.

4.2.2.6 Rated range of calibration gas pressure, within which the uncertainty of calibration is below the specified uncertainty limit, shall be stated.

4.2.2.7 Rated range of gas flow rate, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.2.8 Rated range of interfering components, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

NOTE The interfering components can normally include water vapour, carbon dioxide, nitric oxide, oxygen, hydrogen chloride, carbon monoxide, etc.

4.2.2.9 Rated range of operating ambient temperature, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.2.10 Rated range of operating ambient pressure, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.2.3 Additional limits of uncertainties

4.2.3.1 Gas temperature influence uncertainty.

4.2.3.2 Gas temperature influence uncertainty for calibration.

4.2.3.3 Gas pressure influence uncertainty.

4.2.3.4 Gas pressure influence uncertainty for calibration.

4.2.3.5 Transmittance influence uncertainty.

4.3 Extractive analyzers

4.3.1 Additional operation and maintenance requirements

4.3.1.1 Facilities and requirements for purge

The quality of purge gas such as dust and oil load, concentration limit of measured gas component in the purge gas, and rated range of purge gas pressure and flow rate shall be stated.

4.3.1.2 Facilities and methods for calibration or electronic and optical integrity checking

The rated range of temperature, pressure and flow rate of calibration gas shall be stated.

The gas components and their corresponding concentration levels in calibration gas shall be stated.

4.3.1.3 Facilities and requirements for essential maintenance

Maintenance methods, facilities and the time intervals for maintenance shall be stated.

4.3.2 Additional terms related to the specification of performance

4.3.2.1 Rated minimum transmittance, above which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.3.2.2 Rated range of gas temperature, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.3.2.3 Rated range of gas pressure, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.3.2.4 Rated range of calibration gas temperature, within which the uncertainty of calibration is below the specified uncertainty limit, shall be stated.

4.3.2.5 Rated range of calibration gas pressure, within which the uncertainty of calibration is below the specified uncertainty limit, shall be stated.

4.3.2.6 Rated range of gas flow rate, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.3.2.7 Rated range of interfering components, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

NOTE The interfering components normally include water vapour, carbon dioxide, nitric oxide, oxygen, hydrogen chloride, carbon monoxide, etc.

4.3.2.8 Rated range of operating ambient temperature, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.3.2.9 Rated range of operating ambient pressure, within which the measurement uncertainty of the analyzers is below the specified uncertainty limit, shall be stated.

4.4 Recommended standard values and range of influence quantities

The rated ranges and use of influence quantities for climatic conditions, mechanical conditions and main supply conditions shall be in accordance with those defined in IEC 60654-1, IEC 60654-2, IEC 60654-3.

4.5 Laser safety

The laser classification of light source of analyzer shall be in accordance with those defined in IEC 60825-1.

5 Procedures for compliance testing

5.1 In situ analyzers

5.1.1 General

For the verification of values specifying the performance see IEC 61207-1, together with the following.

The tests considered in 5.1 apply to the complete analyzer as supplied by the manufacturer. The analyzer will be set up in accordance with the instruction delivered by the manufacturer.

5.1.2 Apparatus to simulate measurement condition

The test apparatus for in situ analyzers (see Figure B.1) shall include mechanical components required to present test gases to the measurement path at the appropriate temperature and pressure. For across-duct or open-path analyzers an optical cell is required with transparent wedged windows to minimise optical interference noise. This optical cell should be placed in the uniform temperature region of furnace, and purge tubes are arranged between the analyzer and the optical cell to avoid interference from air. For delay, rise and fall time measurements, another gas cell filled with either zero or span gas is required. Purge tubes and both cells should be of sufficient diameter to accommodate the analyzer beam width. For probe type analyzers, the test apparatus may have a sealed end-cap for the probe, with appropriate gas connections installed. This entire apparatus is then placed within a furnace (see Figure B.2).

To simulate the measurement conditions, it is required that gas absorbance in test conditions is comparable to that in measurement conditions. For example, when the pressure and temperature are the same for measurement and test conditions, the cell length and the gas concentration to be measured can be selected as follows:

$$X_a\ L_a = X_t L_t$$

where

X_a is the maximum gas concentration in the measurement condition;

L_a is the optical path length in the measurement condition;

X_t is the gas concentration in gas cell;

L_t is the length of the optical cell.

5.1.3 Apparatus to generate test gas mixture

Test gas mixture can either use standard gas or gas generated by a test gas generator, which requires at least two gas flow controllers to adjust the flow rates of standard and dilution gases (see Figure B.3). The standard and dilution gases are mixed in a gas mixing device to obtain uniform gas mixture. The concentration of the test component in the gas mixture can be calculated as follows:

$$X_t = X_s R_s / (R_s + R_d)$$

where

X_s is the concentration of the test component in the standard gas;

R_s is the flow rate of standard gas;

X_t is the concentration of the test component in the gas mixture;

R_d is the flow rate of dilution gas.

5.1.4 Apparatus to investigate the attenuation induced by opaque dust, liquid droplets and other particles

Test equipment for in situ analyzers shall include an apparatus to investigate the attenuation induced by dust, liquid droplets and other particles in optical path. Such an apparatus can be a set of neutral density filters or grids with different transmittance to simulate the attenuation induced by opaque dust, liquid droplets and other particles; each grid has square mesh holes as illustrated in Figure B.5.

5.1.5 Testing procedures

5.1.5.1 General

The following relevant testing procedures are detailed in IEC 61207-1:

- intrinsic uncertainty;
- linearity uncertainty;
- repeatability;
- output fluctuation;
- warm-up time;
- variations (influence uncertainties);
- interference uncertainty.

Additional test details required for in situ tuneable semiconductor laser gas analyzers are given below.

5.1.5.2 Drift

The test period should be chosen appropriately for the specific application from the following values:

- 24 h;
- 7 days;
- 30 days;
- 3 months;
- 6 months;
- 1 year.

The readings may be corrected for temperature and pressure variations.

The test procedure detailed in 5.6.5 of IEC 61207-1:2010 is used except the following. Test gas with appropriate stable concentration is applied to the analyzer until a stable indication is given and at least 12 indicated values are recorded continuously, and then average value is calculated. This procedure is carried out at the beginning and end of the specified test period, and at a minimum of six, approximately evenly spread, time intervals within the test period. The drift over the time period is the maximum difference of the calculated average values.

The readings of tuneable semiconductor laser gas analyzers may have periodical fluctuations in hour scale, which is caused by optical interference noise and should be considered as part of the drift. So the slope of linear regression of indicated values as specified in IEC 61207-1 cannot provide an accurate estimate of the drift.

5.1.5.3 Delay time, rise time and fall time

For across-duct and open-path analyzers, perform continuous measurement and wait until a stable indication is given. Insert a gas cell filled with zero (span) gas into the light path (see Figure B.1) and designate this moment as the start time of the step change for falling (rising) delay time. When indicated values become stable, remove the gas cell from the light path and designate this moment as the start time of the step change for rising (falling) delay time. The measurement is continued until the indicated values become stable.

The values for delay time, rise time and fall time as defined in 3.5.13, 3.5.14 and 3.5.15 of IEC 61207-1:2010 are determined from the recorded data, in conjunction with logged time intervals (see Figure B.4).

The time interval of gas cell replacement shall be much shorter than the rise (fall) time of analyzers.

NOTE The procedure for extractive (5.6.6 of IEC 61207-1:2010) analyzers is also applicable for in situ analyzers as long as the gas exchange time is negligible against the response times of the analyzer.

5.1.5.4 Transmittance influence uncertainty

The analyzer is presented with a continued flow of test gas mixture giving a full scale or near full scale indication. The indicated value is recorded until any change in reading is less than or equal to the intrinsic uncertainty of the analyzer. Then sequentially insert the neutral density filters or grids with rated minimum transmittance and at least three neutral density filters or grids whose transmittances approximately evenly spread within the rated range of transmittance into the optical path of analyzer (see Figure B.1), and the indicated values are recorded correspondingly. This procedure shall be repeated at least three times, and the averages of indicated reading for each test transmittance are calculated. The transmittance influence uncertainty is the maximum difference of the calculated average values.

5.1.5.5 Gas temperature influence uncertainty

Control the temperature of the test gas to upper and lower limits of rated range of gas temperature, and to a minimum of three, approximately evenly spread, temperatures within the rated range of gas temperature, and control the pressure of the test gas to the middle of rated range of gas pressure. The indicated values at each temperature are recorded. This procedure is carried out at least three times and the averages of indicated values for each test temperature are calculated. The gas temperature influence uncertainty is the maximum difference of the calculated average values.

5.1.5.6 Gas temperature influence uncertainty for calibration

Control the temperature of the test gas to upper and lower limits of rated range of calibration gas temperature, and to a minimum of three, approximately evenly spread, temperatures within the rated range of calibration gas temperature, and control the pressure of test gas to the middle of rated range of calibration gas pressure. The indicated values at each temperature are recorded. This procedure is carried out at least three times and the averages of indicated values for each test temperature are calculated. The gas temperature influence uncertainty for calibration is the maximum difference of the calculated average values.

5.1.5.7 Gas pressure influence uncertainty

Control the pressure of the test gas to upper and lower limits of rated range of gas pressure, and to a minimum of three, approximately evenly spread, pressures within the rated range of gas pressure, and control the temperature of test gas to the middle of rated range of gas temperature. The indicated values at each pressure are recorded. This procedure is carried out at least three times and the averages of indicated values for each test pressure are calculated. The gas pressure influence uncertainty is the maximum difference of the calculated average values.

5.1.5.8 Gas pressure influence uncertainty for calibration

Control the pressure of the test gas to upper and lower limits of rated range of calibration gas pressure, and to a minimum of three, approximately evenly spread, pressures within the rated range of calibration gas pressure, and control the temperature of test gas to the middle of rated range of calibration gas temperature. The indicated values at each pressure are recorded. This procedure is carried out at least three times and the averages of indicated reading for each pressure are calculated. The gas pressure influence uncertainty for calibration is the maximum difference of the calculated average values.

5.2 Extractive analyzers

5.2.1 General

For the verification of values specifying the performance, see IEC 61207-1, together with the following.

The tests considered in 5.2 apply to the complete analyzer as supplied by the manufacturer. The analyzer will be set up in accordance with the instruction delivered by the manufacturer.

5.2.2 Apparatus to generate test gas mixture

Test gas mixture can either use standard gas or gas generated by a test gas generator, which requires at least two gas flow controllers to adjust the flow rates of standard and dilution gases (see Figure B.3). The standard and dilution gases are mixed in a gas mixing device to obtain uniform gas mixture. The concentration of the test component in the gas mixture can be calculated as follows:

$$X_t = X_s R_s / (R_s + R_d)$$

where

X_s is the concentration of the test component in the standard gas;

R_s is the flow rate of standard gas;

X_t is the concentration of the test component in the gas mixture;

R_d is the flow rate of dilution gas.

5.2.3 Testing procedures

5.2.3.1 General

The following relevant testing procedures are detailed in IEC 61207-1:

- intrinsic uncertainty;
- linearity uncertainty;
- repeatability;
- output fluctuation;
- delay time, rise time and fall time;
- warm-up time;
- variations (influence uncertainties);
- interference uncertainty.

Additional test details required for extractive tuneable semiconductor laser gas analyzers are given below.

5.2.3.2 Drift

The test period should be chosen appropriately for the specific application from the following values:

- 24 h;
- 7 days;
- 30 days;
- 3 months;
- 6 months;
- 1 year.

The readings may be corrected for temperature and pressure variations.

The test procedure detailed in 5.6.5 of IEC 61207-1:2010 is used except the following. Test gas with appropriate stable concentration is applied to the analyzer until a stable indication is given and at least 12 indicated values are recorded continuously, and then average value is calculated. This procedure is carried out at the beginning and end of the specified test period, and at a minimum of six, approximately evenly spread, time intervals within the test period. The drift over the time period is the maximum difference of the calculated average values.

The readings of tuneable semiconductor laser gas analyzers may have periodical fluctuations in hour scale, which is caused by optical interference noise and is considered as part of the drift. So the slope of linear regression of indicated values, as specified in IEC 61207-1, cannot provide an accurate estimate of the drift.

Annex A
(informative)

Systems of tuneable semiconductor laser gas analyzers

Annex A depicts the variety of tuneable laser gas analyzer systems covered by this document.

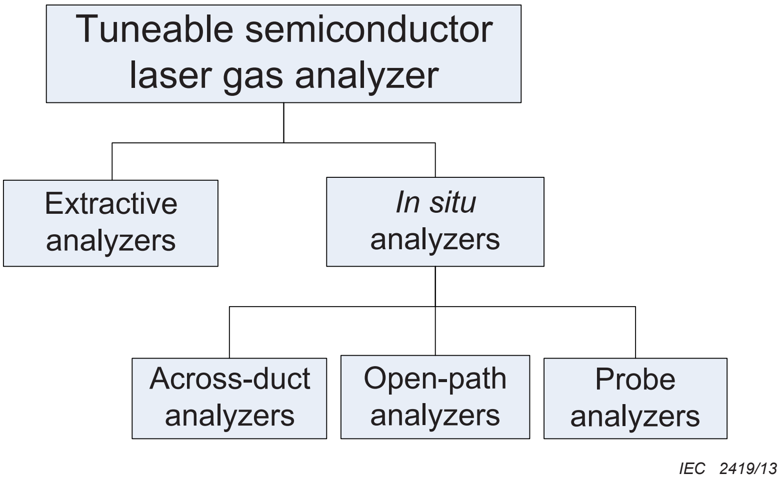


Figure A.1 – Tuneable semiconductor laser gas analyzers

Annex B
(normative)

Examples of the test apparatus

Annex B depicts examples of a variety of tuneable laser gas analyzer test apparatus and techniques.

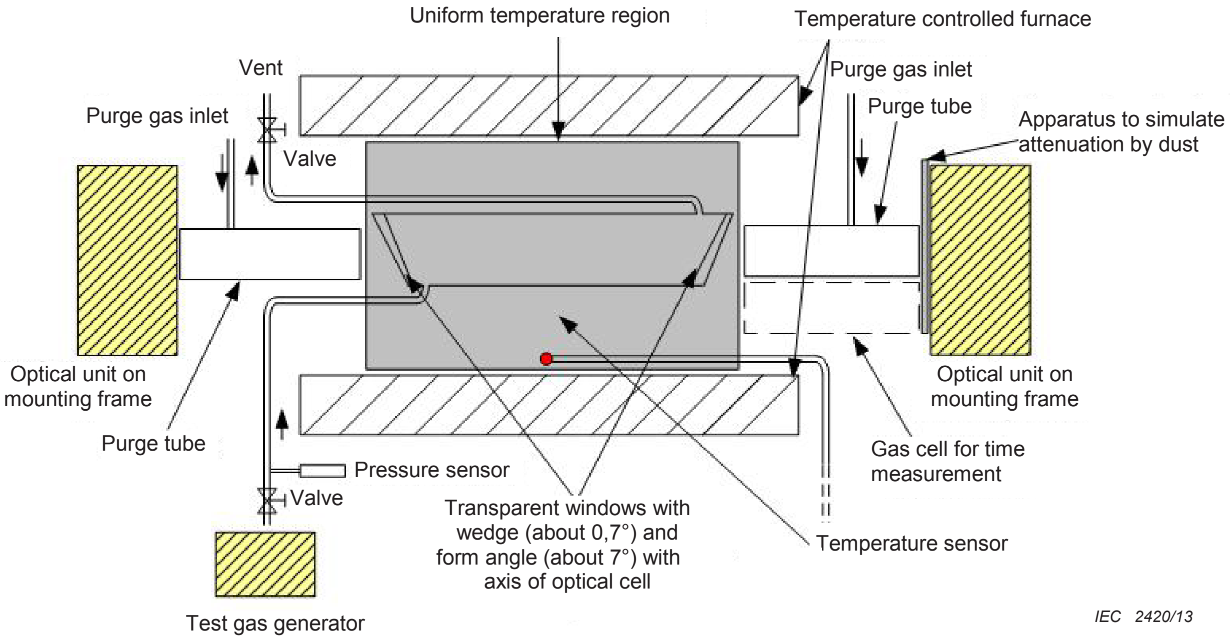


Figure B.1 – Example of a test apparatus to simulate measurement condition for across-duct and open-path analyzers

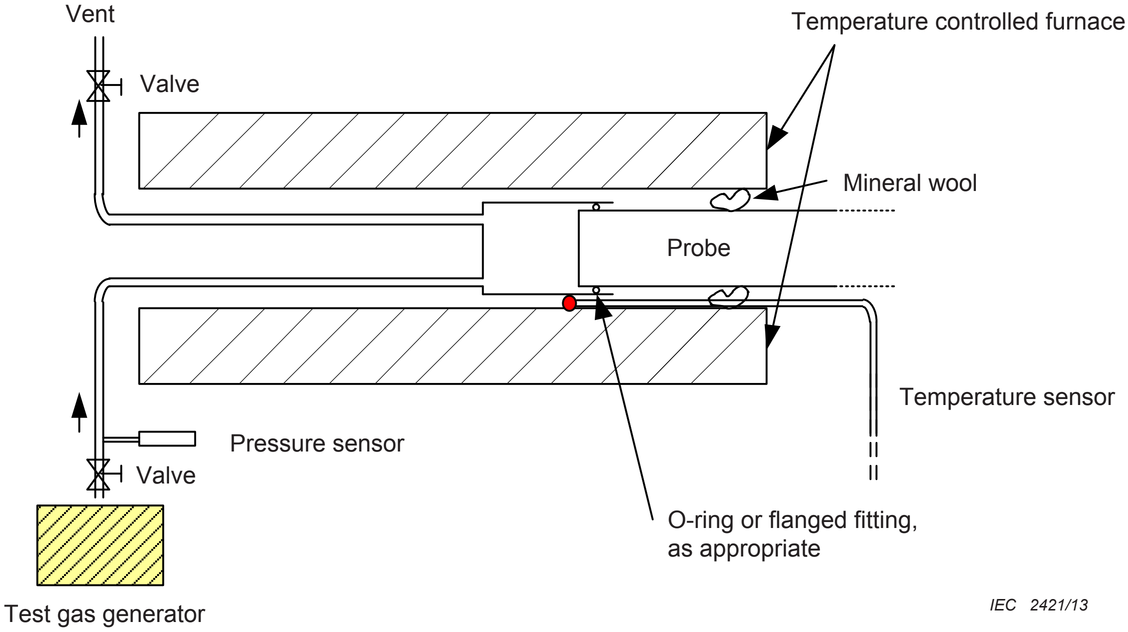


Figure B.2 – Example of a test apparatus to simulate measurement condition for probe type analyzers

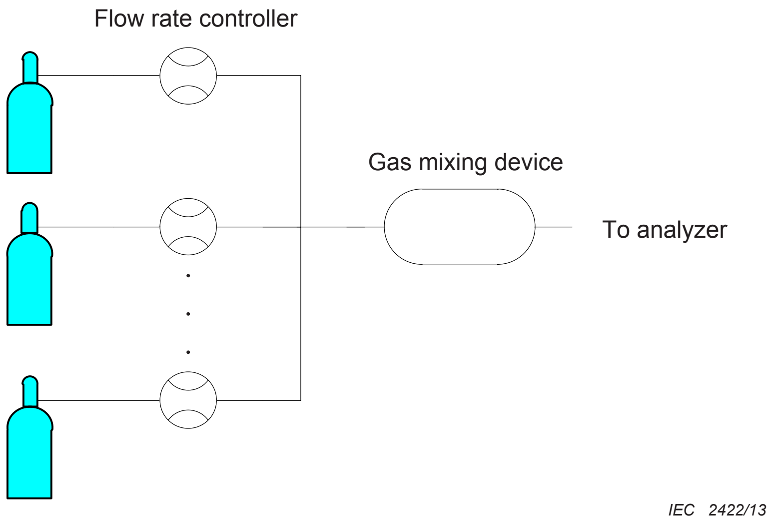


Figure B.3 – Example of apparatus to generate the test gas mixture

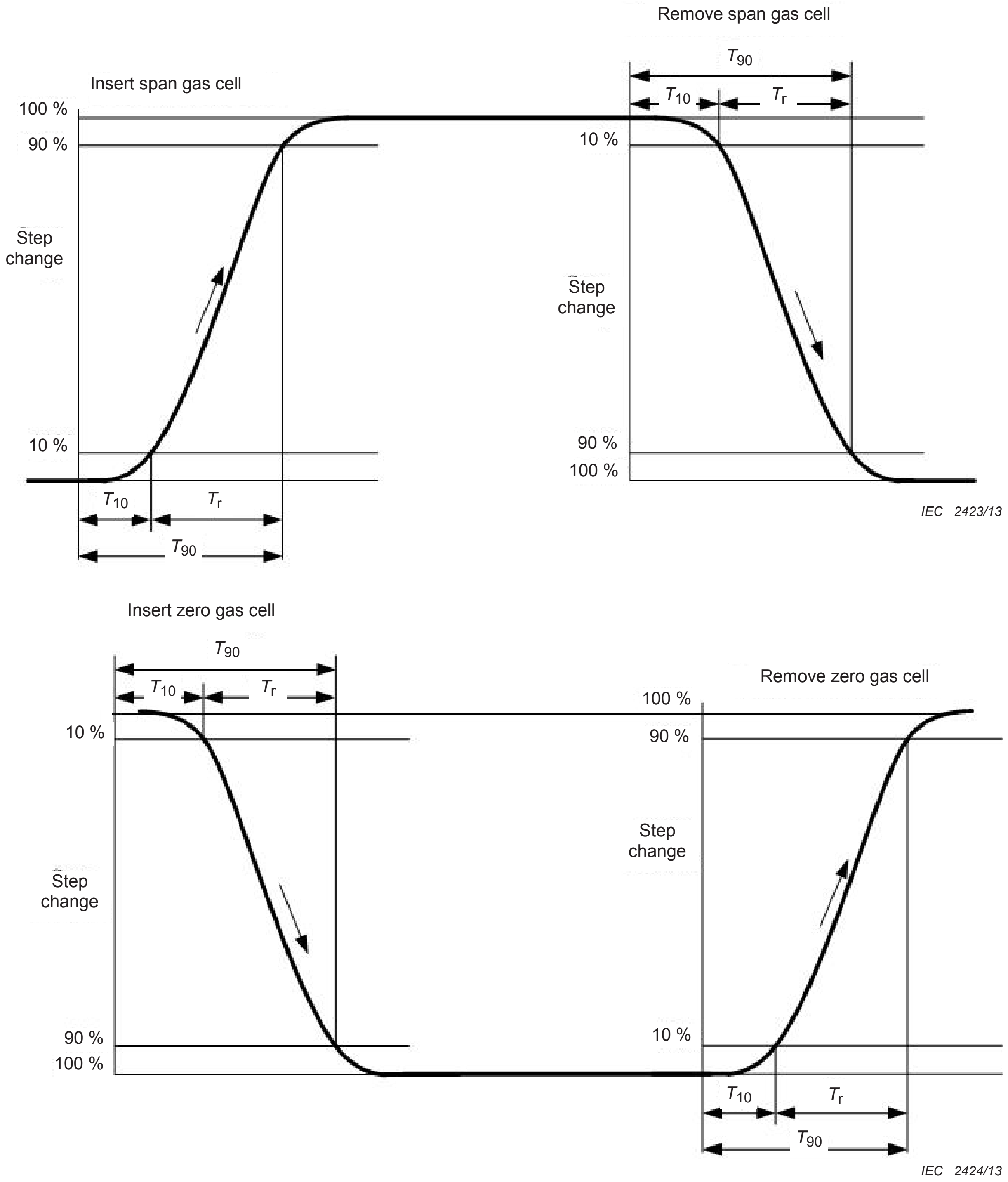
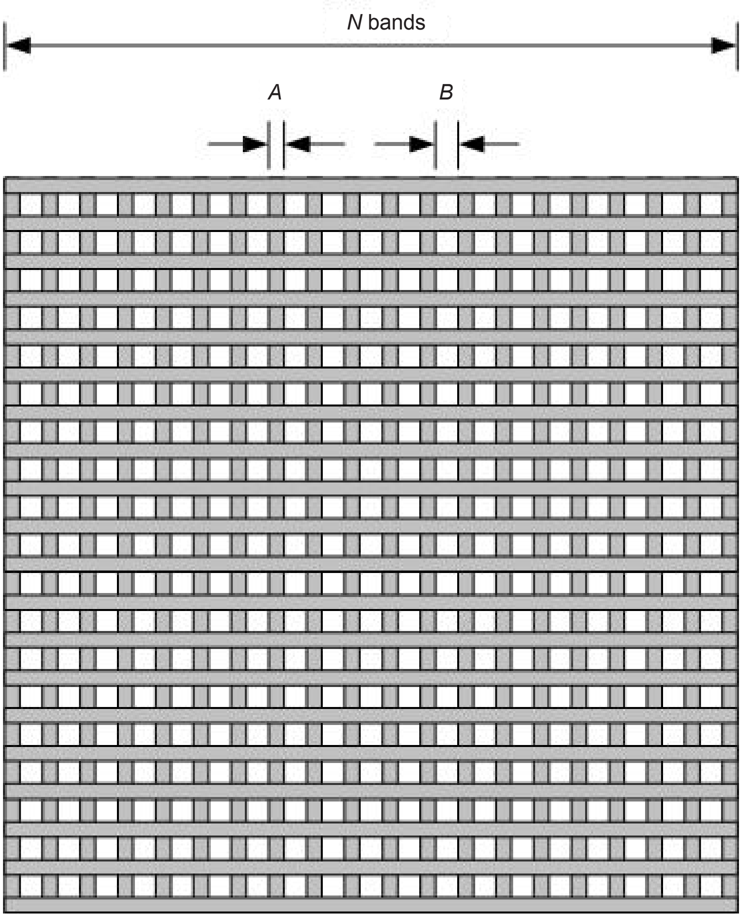


Figure B.4 – Delay time, rise time and fall time



IEC 2425/13

Figure B.5 – Example of a grid to simulate the attenuation by the dust in optical path

Bibliography

ISO 9001, *Quality management systems – Requirements*

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