BS EN 50379-1:2012

BSI Standards Publication

Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances -

Part 1: General requirements and test methods

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 50379-1:2012. It supersedes BS EN 50379-1:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EXL/31/1, Gas detectors.

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

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

ISBN 978 0 580 74636 9

ICS 13.040.40; 91.140.10

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 April 2012.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50379-1

April 2012

ICS 13.320

Supersedes EN 50379-1:2004

English version

Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances - Part 1: General requirements and test methods

Spécification pour les appareils électriques portatifs conçus pour mesurer les paramètres des gaz de combustion dans les conduits d'évacuation des appareils de chauffage - Partie 1: Prescriptions générales et méthodes d'essai

Anforderungen an tragbare elektrische Geräte zur Messung von Verbrennungsparametern von Heizungsanlagen - Teil 1: Allgemeine Anforderungen und Prüfverfahren

This European Standard was approved by CENELEC on 2012-03-19. 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 50379-1:2012 E

Contents

Figure

Tables

Foreword

This document (EN 50379-1:2012) has been prepared by CLC/TC 216 "Gas detectors".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-03-19
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2015-03-19

This document supersedes EN 50379-1:2004.

EN 50379-1:2012 includes the following significant technical changes with respect to EN 50379-1:2004:

— 4.2.12 and 5.7.4 consider 15 min. average concentration for solid fuels;

— 4.3.3 for instructions was amended;

— 5.3.6 for flow indicators was amended;

— 5.5.7 considers calibration curves for sensors with nonlinear signal;

— 5.5.8 considers influence of pressure variations;

— 5.5.9 considers the influence of water vapour on the gas signal;

— 5.7.2 for calculated values was amended;

— 5.9.1 was amended to cover measurement at the circular orifice.

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.

———————

Introduction

This European Standard covers apparatus for measuring gas concentrations and other combustion parameters, as used in the installation and maintenance of heating appliances. It forms a specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances, and includes the following parts under the generic title *Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances*:

Part 1: General requirements and test methods;

Part 2: Performance requirements for apparatus used in statutory inspections and assessments;

Part 3: Performance requirements for apparatus used in non-statutory servicing of gas fired heating appliances.

EN 50379-1 specifies general requirements for the construction, testing and performance of portable spot reading apparatus designed to give an assessment of specific combustion flue gas parameters, such as concentrations of gaseous compounds, temperature and/or pressure, to check the combustion performance of heating appliances for domestic residential and commercial applications, using commercially available fuels.

EN 50379-2 is for apparatus intended to be used for statutory measurement. In several European countries, legal requirements exist for the performance of heating appliances (see Annex A). Authorised inspectors use these apparatus to measure the flue gas parameters, in order to test compliance with national regulations. Due to the legal consequences resulting from the measurement, there are strict requirements regarding the measuring uncertainty of these apparatus, and EN 50379-2 therefore includes maximum values for measuring uncertainty. Tests with real flue gases form a key part of the verification of the performance of the apparatus for statutory measurement. The measuring uncertainty has to be justified by internationally accepted methods over the whole measuring range. The determination of measuring uncertainty is described in Annex C.

EN 50379-3 is for apparatus intended to be used for non-statutory applications. There are reduced performance requirements, because the apparatus are designed to decide whether maintenance for a gas fired appliance is required, and for adjusting the appliance during maintenance. There will be no determination of the measuring uncertainty for the apparatus.

1 Scope

This European Standard covers apparatus for measuring gas concentrations and other combustion parameters, as used in the installation and maintenance of heating appliances. Such apparatus may be used for testing the performance of appliances for different types of fuels, either by the installer, maintenance engineer or inspector.

The apparatus may consist of different functional modules, which may be tested separately for complying with this standard and will be combined in different ways according to the different applications. This part of EN 50379 specifies the general requirements and is supplemented by the requirements in EN 50379-2 and/or EN 50379-3.

This European Standard specifies general requirements for the construction, testing and performance of portable spot reading apparatus designed to give an assessment of specific combustion flue gas parameters, such as concentration of gaseous compounds, temperature and/or pressure, to check the combustion performance of heating appliances for domestic residential and commercial applications, using commercially available fuels.

This European Standard excludes apparatus for

- continuous emission, safety monitoring and control, and
- use in vessels with an international load line.

NOTE 1 When this apparatus is used in industrial premises national regulations may apply.

NOTE 2 Apparatus may contain functional modules which are not covered by this standard e.g. measurement of smoke spot number (see EN 267:2009+A1:2011, Annex A) and/or measurement of indoor ambient air (see EN 50543).

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.

EN 267:2009+A1:2011, *Automatic forced draught burners for liquid fuels*

EN 297, *Gas-fired central heating boilers – Type B11 and B11BS boilers, fitted with atmospheric burners of nominal heat input not exceeding 70 kW*

EN 676, *Automatic forced draught burners for gaseous fuels*

EN 50270:2006, *Electromagnetic compatibility – Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen*

EN 50271:2010, *Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen – Requirements and tests for apparatus using software and/or digital technologies*

EN 50379-2:2012, *Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances – Part 2: Performance requirements for apparatus used in statutory inspections and assessment*

EN 50379-3:2012, *Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances – Part 3: Performance requirements for apparatus used in non-statutory servicing of gas fired heating appliances*

EN 50543, *Electronic portable and transportable apparatus designed to detect and measure carbon dioxide and/or carbon monoxide in indoor ambient air – Requirements and test methods*

EN 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal) (IEC 60068-2-6)*

EN 60335-1:2002, *Household and similar electrical appliances – Safety – Part 1: General requirements (IEC 60335-1:2001, mod.)*

EN 60359:2002, *Electrical and electronic measurement equipment – Expression of performance (IEC 60359:2001)*

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

CR 1404:1994, *Determination of emissions from appliances burning gaseous fuels during type-testing*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 60359:2002, 2.1 and the following apply.

3.1
domestic residential and commercial premises
any place of residence of a household, family or person (whether temporary or permanent) and commercial premises whether residential or not and including recreational boats, caravans and mobile homes

3.2
ambient air
normal atmosphere surrounding the apparatus

3.3
clean air
ambient air which is essentially free of flue gas and of interfering or contaminating substances

3.4
synthetic air
technically produced air consisting of oxygen and nitrogen

3.5
sensor
assembly in which the sensing element is housed and which may contain associated circuit components

3.6
sensing element
device, the output of which will change with variation of the parameter of interest

3.7
spot reading
apparatus intended to be used for short periods of time in the range of minutes, as required

3.8
volume ratio (V/V)
ratio of the volume of a component to the volume of the gas mixture under specified conditions of temperature, pressure and relative humidity

3.9
mains powered apparatus
apparatus designed to be powered by the domestic mains electrical supply with or without an additional power source

3.10
battery powered apparatus
apparatus designed to be energised from batteries alone, whether disposable or rechargeable

3.11
probe
part of the apparatus that is placed in the stack or flue of the heating appliance, for the purpose of sampling the gas and/or for measuring temperature or pressure

3.12
initial start up delay
time taken for the apparatus to reach the operating mode from switch-on, or after replacing batteries, or following power failure in the case of mains powered equipment

3.13
calibration
process of determining the deviation of an apparatus relative to a reference

3.14
reference
in laboratory tests, a reference gas will be a certified calibration gas cylinder. For real gas measurement, the reference is a measuring device with high accuracy (e.g. as specified in EN 267). For temperature and pressure measurement, the reference is a measuring device with certification proving traceability to a national or international metrology institute

3.15
adjustment
process of tuning the apparatus, in order to return the deviation found in calibration to within the admissible error

3.16
functional module
all components required for one measurement task, including both hardware and software

Note 1 to entry: A functional module may consist of one or more separate pieces of equipment or may be completely integrated with the apparatus.

3.17
response time (t_{90})
time interval with the apparatus in a warmed-up condition, between the time when an instantaneous variation of the parameter to be measured is produced at the apparatus inlet, and the time when the response reaches and remains beyond 90 % of the final indication

4 General requirements

4.1 General

The apparatus shall reliably measure specific combustion flue gas parameters and shall clearly display the result. If the apparatus is equipped with a sampling system (probe) the gas sample shall be drawn into the unit for analysis via the sampling system for all tests. All parts of the apparatus shall conform to the construction requirements of 4.2 and the performance requirements in EN 50379-2 and/or EN 50379-3.

4.2 Construction

4.2.1 General

All parts of the apparatus, including the sensor(s), shall be constructed of materials that will not be adversely affected by vapours and gases or chemical substances to be expected during normal operation of the apparatus, see 4.3.3 h). Similar consideration shall also be given to the sampling system and components that can be in contact with the gas, as appropriate. The probe shall be constructed of materials that will not be adversely affected by environmental conditions found in heating appliances within the scope of this standard.

4.2.2 Sampling system

The sampling system of the apparatus shall be so constructed as to prevent damage to the sensor(s) and pump by particulate matter and liquids that may be expected during normal operation of the apparatus. Means shall be provided to recognise and/or indicate the working mode of the pump by, for example

- pump noise,
- visual indication, or
- flow measurement.

Condensation or absorption effects have to be considered, and shall have no significant influence on the indicated values, particularly when determining SO_2 and NO. The probe shall be constructed in such a manner that droplets of condensation will not influence the result of temperature measurements even when the probe is held vertically. In addition the temperature sensing element shall not touch the probe outer sheath. If simultaneous recording of temperature and gaseous compounds is required, the probe shall be constructed such that the distance between the sensing element for temperature and the gas inlet, is less than 8 mm. If probes of different lengths are provided the shortest and the longest shall be tested with the instrument.

NOTE For apparatus intended to measure heating combustion efficiency (see Annex A) reference should be made to national regulations where appropriate. Typically the following dimensions have been shown to be suitable:

- sampling probe immersion depth of at least 150 mm;
- probe external diameter between 6 mm and 13 mm (required for the measurement of heat loss only); and
- adjustable depth stop to be provided, to fix probe position and cover measuring aperture up to 21 mm diameter, to prevent air ingress.

The method of testing tightness of the complete gas sampling system, as specified by the manufacturer, shall be checked and verified for use in practice.

4.2.3 Adjustments

Access to sensitivity controls shall only be possible by the use of special tool or a software passcode or by destroying a special seal. Any regular checks shall be performed automatically or by access as described above.

4.2.4 Power supply

Apparatus which derives its power from internal batteries may give a visual warning before the battery capacity falls to a point where either the apparatus sensitivity or the stated display accuracy falls outside the requirements. When this point is actually reached, a clear indication shall be given to alert the user and the display shall switch out of normal operational mode.

4.2.5 Display

Indicators shall be provided to show the following:

- measured parameter(s), value(s) and physical unit;
- low battery warning;
- mode of operation or instrument status (e.g. warm-up, measurement);
- when values lie outside the indicating range; and
- software version.

All values shall be indicated on a display with characters not less than 8 mm high unless adequate provision is made for enhancing the legibility (e.g. backlighting) in which case the minimum character height shall be 4 mm.

For each separate parameter measured the apparatus shall display the value, the physical unit and parameter description. For a combination of parameters the display may switch automatically from one indication to another. If the display switches between information of simultaneous parameters it shall be clear and understandable. Displayed measured values shall be refreshed at intervals no greater than 3 s. If the apparatus is equipped with seven-segment displays it shall have a device or self testing function for checking the displays.

4.2.6 Measuring range and resolution

Table 1 lists the different parameters covered by this standard. For each parameter given it specifies

- minimum indication range;
- minimum display resolution;
- accuracy of the apparatus;
- the detection limit; and
- maximum response time.

4.2.7 Indication range

The indication ranges are the minimum ranges for the apparatus. Higher ranges are allowed, but will not change the values for accuracy or detection limit.

4.2.8 Accuracy of the apparatus

The values in Table 1 e.g. "± 20 ppm or 5 % rel." have the meaning: "The permitted deviation is up to ± 20 ppm or ± 5 % of the reading, whichever is the greater".

4.2.9 Detection limit

Values indicated below the detection limit are not significant.

4.2.10 Efficiency

Efficiency is not included in the table as determination varies considerably from country to country (see Annex A for further details).

Table 1 – Requirements for accuracy

Parameter	Indication range	Display resolution	Accuracy	Detection limit	Response time (t_{90})
CO (low)	0 ppm - 200 ppm	1 ppm	± 10 ppm or 10 % rel.	10 ppm	90 s
CO (medium)	0 ppm - 2 000 ppm	1 ppm	± 20 ppm or 5 % rel.	20 ppm	90 s
CO (high)	0 ppm - 20 000 ppm	10 ppm	± 100 ppm or 10 % rel.	100 ppm	90 s
NO	0 ppm - 600 ppm	1 ppm	± 5 ppm or 5 % rel.	5 ppm	90 s
SO_2	0 ppm - 500 ppm	1 ppm	± 10 ppm or 5 % rel.	10 ppm	180 s
O_2	0 %- 21 % V/V	0,1 %	± 0,3 % V/V	0,3 % V/V	30 s
CO_2	0 % - 20 % V/V	0,1 %	± 0,3 % V/V	0,3 % V/V	50 s
Temperature (flue gas)	0 °C - 400 °C	1 °C	± 2 °C or 1,5 % rel.	1 °C	for EN 50379-2: 30 s for EN 50379-3: 50 s
Temperature (inlet air)	0 °C - 100 °C	1 °C	± 1 °C	1 °C	70 s
Pressure (draught and circular orifice differential pressure)	-50 Pa to +200 Pa	1 Pa	± 2 Pa or 5 % rel.	1 Pa	10 s
Pressure (differential)	0 Pa - 10 000 Pa	10 Pa	± 50 Pa or 1 % rel.	100 Pa	10 s
Heat loss	0 % - 100 %	0,1 %	N/A [a]	N/A [a]	N/A
CO/CO_2 ratio	0 – 0,01	0,000 1	N/A [b]	N/A [b]	N/A

[a] Calculated from the fuel characteristics and measured parameters - either O_2 or CO_2, temperature of flue gas and temperature of inlet air, in accordance with national regulations.

[b] Calculated from the fuel characteristics and the measured parameters of CO and either O_2 or CO_2, in accordance with national regulations.

4.2.11 Printer or data storage

If the apparatus is provided with a printer or any means for data storage e.g. a data logger it shall print the date, time and values of all parameters, as specified in 4.2.6, taken at the time of the printout.

4.2.12 Average concentration (apparatus intended for appliances burning solid fuels)

The apparatus intended to be used for appliances burning solid fuels shall be able to carry out a measurement for oxygen and CO over a defined period. For the purpose of type testing the period is specified with 15 min. After finishing the measurement the concentration shall be indicated as average value.

The sample rate for averaging shall be minimum one per second.

NOTE The period for averaging may be different in national regulations.

The time period for averaging shall be in conformance with national regulations.

4.3 Labelling and instructions

4.3.1 General

The text used for labels and instructions shall be in accordance with appropriate national regulations.

4.3.2 Labelling

Durable label(s) shall be carried on the apparatus, or moulded into the casing, giving at least the following information:

a) the manufacturer's or supplier's name, trademark or other means of identification;

b) the type of apparatus, e.g. "combustion gas analyser", and model name or number;

c) either the number of this European Standard or the third party certification;

d) the manufacturer's serial number and/or production batch date code;

e) the replacement battery and mains power requirements, as relevant;

f) whether or not the instrument is suitable for outdoor use (see 5.3.2, 5.5.3 and 5.6.3).

Item (e) shall be clearly visible if the batteries are being changed.

External label(s) shall comply with EN 60335-1:2002, 7.6 and 7.14.

4.3.3 Instructions

The apparatus shall be provided with an instruction manual giving complete, clear and accurate instructions for the safe and proper operation and regular checking of the apparatus. It shall also include the following:

a) a statement of compliance with Part 2 and/or Part 3 of this European Standard, specified for the whole apparatus or for the defined functional module(s);

b) the specific type(s) of fuel for which the apparatus is intended to be used;

c) the correct battery type(s) and method of replacing or recharging batteries, for battery powered units, details of mains voltage, frequency and fuse rating, if relevant, and a warning of the possible hazards of electric shock or malfunction, if tampered with;

d) warnings against continuous use, or use as a safety alarm;

e) an explanation of all indications including information on values calculated, not measured;

f) for apparatus complying with Part 2, the recommended minimum time required to perform one complete measurement cycle and achieve correct indication of the measured values(s);

g) for apparatus complying with Part 3, the recommended minimum time required for one checking procedure;

h) a list of commonly occurring materials, vapours or gases (e.g. cleaning fluids, polishes, paints, cooking operations, etc.) which may affect the operation or reliability of the apparatus, in the short or long term;

i) guidance on the life expectancy of the sensor(s) and batteries;

j) details of operational limitations, including ambient temperature and humidity ranges, and whether the apparatus is intended to be placed in an appropriate case during transportation and/or normal operation;

k) details of initial start up delay following switch on and after battery replacement;

l) instructions for checking, testing and/or replacing sensing elements (where applicable) dust filter and water trap, and calibration and/or adjustment of the apparatus on a routine basis;

m) a warning that, when using the apparatus, a full visual inspection of the appliance shall also be carried out to ensure its safe operation;

n) a warning of potential error due to solubility of target gas in water if the apparatus contains a water trap or filter;

o) instructions for testing leaks and/or blockages of the gas sampling system (see also 5.3.6);

p) all user changeable parameters and their valid ranges;

q) life time of data storage if a back-up battery is used for preserving the data content of parameter memory when the supply voltage is removed.

5 Test methods

5.1 General requirements for tests

5.1.1 General

The manufacturer shall specify for which fuel(s) and for which parameters or combination of these, the apparatus or module(s) shall be tested as described in this clause and shall comply with the performance requirements listed under the corresponding clause numbers in Part 2 and/or Part 3 of this standard. All relevant tests of this standard shall be carried out.

Apparatus may contain functional modules which are not covered by this standard, e.g. measurement of smoke spot number (see EN 267:2009+A1:2011, Annex A) and/or measurement of indoor ambient air (see EN 50543).

If the apparatus has a modular structure allowing different combinations of parameters to be measured and displayed with different accessories, such as with probes or filters fitted, it shall clearly state in the manual which parameters and combinations are tested to comply with which parts of this standard or additional standards (e.g. EN 267 or EN 50543).

NOTE Modules added at a later stage for additional parameters may be tested separately.

5.1.2 Samples and sequence of tests

Details of the samples needed and the sequence of testing to be followed are given in EN 50379-2:2011, 5.1.2 and EN 50379-3:2011, 5.1.2, as appropriate. Tests shall first be carried out to ensure that the apparatus satisfies the constructional requirements of 4.2 and the requirements for labelling and instructions of 4.3 as appropriate.

5.1.3 Preparation of samples

The sample apparatus shall be prepared in accordance with the manufacturer's instructions. If the apparatus is normally used in its carrying case then the test shall be carried out with the apparatus in the carrying case.

5.1.4 Test facility

The construction of the test gas delivery system shall be such as to ensure that the gas sensor(s) are exposed to a specific volume ratio of test gas in a reproducible manner. The flow rate of test gas shall be matched to the sampling rate of the apparatus without causing significant pressure variations.

5.2 Normal conditions for tests

5.2.1 General

The normal test conditions in 5.2.2 to 5.2.8 shall be used for all tests unless otherwise specified.

5.2.2 Cylinder test gases

5.2.2.1 Requirements

The cylinder test gases listed below shall be

- used to perform the tests in 5.3.4, 5.3.5, 5.4.2 to 5.4.4, 5.5.3 to 5.5.7, 5.5.9, 5.6.5 to 5.6.7, 5.7.3 and 5.7.4,
- within the range of ± 5 % relative (for volume ratios below 100 ppm within ± 10 % relative) of the volume ratios given in the tables, but known within ± 2 % relative and greater than 99,99 % purity for nitrogen.

5.2.2.2 Test gas mixtures for O_2 and/or CO_2 sensors

When fitted with an oxygen and/or carbon dioxide sensor the apparatus shall be tested with gases of known volume ratio as shown in Table 2.

Table 2 – Test gas mixtures for O_2 and/or CO_2 sensors

Gas mixture	O_2	CO_2	CO	SO_2 [a]	C_3H_8	Balance
1	1,6 %	12,0 %	950 ppm	80 ppm	70 ppm	Nitrogen
2	5,0 %	9,0 %	150 ppm	80 ppm	70 ppm	Nitrogen
3	16,5 %	2,5 %	950 ppm	80 ppm	70 ppm	Nitrogen

[a] To be omitted, at the manufacturer's request, when the apparatus under test is intended only for use with natural gas and/or LPG.

5.2.2.3 Test gas mixtures for low range CO sensors

When fitted with a sensor for measuring carbon monoxide in the low range the apparatus shall be tested with gases of known volume ratio as shown in Table 3.

Table 3 – Test gas mixtures for low range CO sensors

Gas mixture	CO	H_2 [a]	Balance
1	150 ppm	75 ppm	Air
2	50 ppm	—	Air

[a] To be omitted, at the manufacturer's request, when the apparatus under test is intended only for EN 50379-3.

5.2.2.4 Test gas mixtures for medium range CO sensors

When fitted with a sensor for measuring carbon monoxide in the medium range the apparatus shall be tested with gases of known volume ratio as shown in Table 4.

Table 4 – Test gas mixtures for medium range CO sensors

Gas mixture	O_2	CO	H_2 [a]	CH_4	Balance
1	2,5 %	950 ppm	500 ppm	—	Nitrogen
2	-----	950 ppm	—	—	Air
3	-----	150 ppm	—	150 ppm	Air

[a] To be omitted, at the manufacturer's request, when the apparatus under test is intended only for EN 50379-3.

5.2.2.5 Test gas mixture for high range CO sensors

When fitted with a carbon monoxide sensor for the high measuring range the apparatus shall be tested with gas of known volume ratio as shown in Table 5 in addition to the gas mixtures shown in Table 4.

Table 5 – Test gas mixture for high range CO sensors

Gas mixture	CO	Balance
1	8 000 ppm	Air

5.2.2.6 Test gas mixtures for NO sensors

When fitted with a nitric oxide sensor the apparatus shall be tested with gases of known volume ratio as shown in Table 6.

Table 6 – Test gas mixtures for NO sensors

Gas mixture	NO	Balance
1	50 ppm	Nitrogen
2	200 ppm	Nitrogen
3	450 ppm	Nitrogen

5.2.2.7 Test gas mixtures for SO_2 sensors

When fitted with a sulphur dioxide sensor the apparatus shall be tested with gases of known volume ratio as shown in Table 7.

Table 7 – Test gas mixtures for SO_2 sensors

Gas mixture	SO_2	Balance
1	50 ppm	Air
2	200 ppm	Air
3	450 ppm	Air

5.2.3 Measurements on heating appliances

For flue gas measurement under realistic conditions (including the influence of high humidity and cross interferences with other compounds of the flue gas) it is essential to test with heating appliances using the type(s) of fuel for which the apparatus is designed. The following appliances shall be used for the relevant tests:

a) atomizing oil burners of monobloc type (for extra light fuel oil) as defined in EN 267;

b) automatic forced draught burners for gaseous fuels as defined in EN 676;

c) gas-fired central heating boilers with atmospheric burners as defined in EN 297.

For apparatus designed to measure the flue gas of gaseous fuels, both types of burners b) and c) shall be used.

Suitable appliances for additional type testing with solid fuels (e.g. coal and wood) or other types of fuel will be chosen at the discretion of the test house. In this case, the test house shall take particular care to keep detailed records of all test conditions.

5.2.4 Power supply

Unless otherwise specified for the particular test mains voltages shall be within ± 2 % of the nominal values quoted by the manufacturer. Battery powered apparatus shall be fitted with new or fully charged battery/batteries at the start of each test, where appropriate.

For flue gas tests only the mains voltage supply may be allowed to vary ± 10 % from nominal values.

5.2.5 Temperature

Unless otherwise specified for the particular test the *synthetic air* and test gas mixtures shall be at a constant temperature ± 2 °C, within the range 15 °C to 25 °C for the duration of each test.

For flue gas tests only the ambient air temperature may rise to a maximum of 40 °C.

5.2.6 Humidity

Unless otherwise specified for the particular test the ambient air shall be at a constant relative humidity ± 10 % within the range 30 % to 70 % for the duration of each test.

5.2.7 Pressure

Except for 5.5.8, 5.6.4 and 5.8.7 tests shall be performed using air, test gas and real flue gas at constant pressure ± 1 kPa within the range of 86 kPa to 108 kPa throughout the duration of the test.

5.2.8 Exchangeable parts

If the manufacturer supplies different types of accessories or optional filters, water traps and/or probes for the same parameter measurement, then the apparatus shall be tested under the conditions which give the most unfavourable result for the test being conducted.

5.3 Mechanical tests

5.3.1 General

If the apparatus is designed to be used in a protection case this shall be clearly mentioned in the instruction manual and shall be subjected to the mechanical tests from 5.3.3 to 5.3.5 in this protection case.

5.3.2 Degree of protection

The enclosure of the apparatus shall provide at least an IP40 degree of protection when all probes etc. are connected, in accordance with EN 60529:1991, Clauses 12 and 14. If an apparatus is designed for outdoor use it shall provide at least an IP42 degree of protection when connected similarly. The apparatus shall be tested in accordance with EN 60529:1991, Clauses 12 and 14.

5.3.3 Impact strength

The apparatus shall be tested in accordance with the test specified in EN 60335-1:2002, Clause 21, with the following modification to the third paragraph:

“The apparatus is rigidly supported, and three blows are applied to every point of the enclosure that is likely to be weak with an impact energy of (1,0 ± 0,2) J".

5.3.4 Vibration

The appropriate test, as defined in EN 60068-2-6, shall be applied with the following parameters:

NOTE The test may be replaced by the procedure 1 from EN 60079-29-1.

- frequency range 10 Hz to 150 Hz;
- vibration amplitude 0,35 mm;
- duration of endurance 10 sweep cycles per axis.

Mount the apparatus in its normal operating orientation and apply the vibration along each of the three mutually perpendicular major axes in turn. Subject the apparatus to one of the most appropriate test gas mixtures as described in 5.2.2.

5.3.5 Drop

Drop the apparatus, including the probe and any interconnecting wiring and tubing, in its normal operating orientation from a height of 0,5 m onto concrete. The apparatus shall be subjected to this test in a case intended to provide protection during transportation, if one is supplied with the apparatus. Subject the apparatus to one of the most appropriate test gas mixtures as described in 5.2.2.

5.3.6 Flow indicator (if fitted)

For apparatus fitted with an integral flow indicator blockage of the gas path shall be simulated. Operation of the apparatus shall be checked by visual inspection to ensure that the blockage is recognised and that appropriate warning is given and incorrect measured values are not displayed.

If no flow indication is provided the user manual has to specify that the test for leaks and/or blockages (see 4.3.3 o)) shall be carried out before each use of the equipment.

5.3.7 Dust filter and water trap

Install the test apparatus on an oil burning appliance with a smoke spot number of 4,0 ± 0,5 for 1 h (see EN 267:2009+A1:2011, Annex A). At the request of the manufacturer this test may be performed with the sensor(s) removed.

Install the test apparatus on a natural gas burning appliance with a flue gas dewpoint of about 50 °C for 1 h.

After testing the water trap and the dust filter shall be checked by visual inspection.

5.4 Electrical and software tests

5.4.1 Electromagnetic Compatibility (EMC)

Test the apparatus, including the probe and any interconnecting wiring and tubing, for electromagnetic compatibility in accordance with EN 50270 for Type 1 (domestic) and shall meet the requirements of EN 50270:2006, Table 5.

5.4.2 Supply voltage variations (not applicable to battery powered apparatus)

Power the equipment at the rated supply voltage U_n and frequency. Subject the apparatus to one of the test gas mixtures for all gas parameters to be tested as described in 5.2.2, at a rated supply voltage of U_n + 10 %. Repeat the test at a supply voltage of U_n – 10 %.

5.4.3 Battery fault condition (applicable only to battery powered apparatus)

Connect the apparatus to a stabilized power supply and set to the rated battery voltage. Decrease the supply voltage in steps of 0,1 V, at intervals of at least 1 min, until the battery fault warning is given. Record the supply voltage at which the fault condition is given as U_e. Set the supply voltage one step above U_e and subject the apparatus to one of the test gas mixtures for all gas parameters to be tested as described in 5.2.2.

5.4.4 Battery reversal (applicable only to battery powered apparatus)

The battery reversal test shall be applied to apparatus incorporating replaceable batteries if there is any possibility of the apparatus being subjected to reversed polarity of supply during normal battery replacement. In this case, remove the battery and insert it into the apparatus with reverse polarity, switch on the apparatus, then remove the battery and reinsert it with correct polarity. Switch on the apparatus and subject it to one of the test gas mixtures for all gas parameters to be tested as described in 5.2.2.

5.4.5 Software and digital techniques

Software and digital components shall comply with EN 50271:2010, 4.1.1 to 4.1.3, 4.4, 5.1 and 5.2 including 5.1.c requiring a software documentation according to 4.3.4.

5.5 Tests with test gases

5.5.1 General

There shall be no adjustment of the apparatus during the whole sequence of tests 5.5.3 to 5.6.6.

Gas measurements:

i) expose the apparatus to the relevant test gas mixtures, as specified below, for 3 min, or 5 min when exposed to test gases in 5.2.2.7;

ii) expose the apparatus to clean air until the indication is below the detection limit, or for a maximum of 3 min or 10 min for test gases in 5.2.2.5 and 5.2.2.7.

Repeat i) and ii) above until all relevant test gas mixtures have been applied. In addition to recording the displayed reading of the appropriate test gases also record the displayed reading of all other relevant gases.

NOTE Test 5.5.3 may show a discrepancy with the pre-calibration results, and this could be caused by the use of different test gases. In this case, it is permissible to make minor adjustments to the apparatus. Test 5.5.3 should then be repeated, before starting the subsequent sequence of tests.

In the case of individual modules being tested separately one relevant test gas may be chosen as being representative rather than applying the full series of test gases specified in 5.2.2.

5.5.2 Unpowered storage

The apparatus (including the battery, if the manufacturer supplies this item with the product) shall be exposed sequentially to a temperature of (–20 ± 2) °C for 24 h, ambient temperature for 24 h, (50 ± 2) °C for 24 h and ambient for 24 h. The apparatus shall then be energised and subjected to one of the test gas mixtures as described in 5.2.2 following the method described in 5.5.1.

5.5.3 Initial performance test

The apparatus shall be tested with all relevant test gases in accordance with 5.2.2 following the method described in 5.5.1 at (5 ± 2) °C, or (–5 ± 2) °C for equipment designed for outdoor use, after being exposed to that temperature for at least 1 h. The apparatus shall be allowed to stabilise at (20 ± 2) °C for at least 1 h. The apparatus shall then be tested again with all relevant test gases in accordance with 5.2.2 following the method described in 5.5.1 at (40 ± 2) °C, after being exposed to that temperature for at least 1 h.

5.5.4 Response time

Expose the apparatus to the relevant test gases, in accordance with 5.2.2 following the method described in 5.5.1, as follows:

- CO (low range): test gas (5.2.2.3) mixture 1;
- O_2 and CO_2: test gas (5.2.2.2) mixture 2;
- CO (medium range) NO and SO_2: test gas (5.2.2.4), (5.2.2.6) or (5.2.2.7) mixtures 1 and 3;
- CO (high range): test gas (5.2.2.5) mixture 1.

Switch on the apparatus and purge with ambient air. Apply the relevant test gases one after the other. Measure the time between applying the test gas and the displayed value reaching 90 % of the test gas value.

After each test gas application the apparatus shall be purged with ambient air.

5.5.5 Cold start

Store the complete apparatus and accessories at (0 ± 2) °C for at least 2 h, then transfer the whole apparatus to (20 ± 2) °C and not more than 50 % RH and immediately switch on, following the manufacturer's instructions. After a further 10 min expose the apparatus to the relevant test gases in accordance with 5.2.2 following the method described in 5.5.1 as follows:

- CO (low range): test gas (5.2.2.3) mixture 1;
- O_2 and CO_2: test gas (5.2.2.2) mixture 2;
- CO (medium range) NO and SO_2 : test gas (5.2.2.4), (5.2.2.6) or (5.2.2.7) mixtures 1 and 3;
- CO (high range): test gas (5.2.2.5) mixture 1.

5.5.6 Zero reading

Expose the apparatus to nitrogen in accordance with 5.5.1 for 3 min. Then apply pure test gas for each gas parameter to be tested in the relevant measuring range in accordance with 5.5.1 for 5 min. This procedure shall be done 4 times.

5.5.7 Calibration curve for sensors with non-linear signal

The calibration curve of measuring principles having a nonlinear signal shall be checked by 5 calibration points at 10 %, 25 %, 50 %, 75 % and 90 % of the measuring range. This test shall be determined as the initial performance test 5.5.3 and the final test 5.6.6.

The accuracy of each of the calibration gas shall be better than one third of the required apparatus accuracy.

NOTE 1 The deviations to linear output of electrochemical oxygen sensors is so small that these sensor types will be considered as linear.

NOTE 2 The characteristic of different measuring principles is explained in detail in EN 45544-4.

5.5.8 Pressure variation

For sensing principles which are sensitive to pressure variation, e.g. infrared sensors a test shall be carried out with one of the test gas mixtures for all gas parameters to be tested in accordance with 5.2.2 following the method described in 5.5.1 at (95 ± 0,5) kPa, (100 ± 0,5) kPa, and (105 ± 0,5) kPa.

The pressure shall be maintained at the specified levels for 5 min, before a reading is accepted or a test is made.

5.5.9 Influence of water vapour

The influence of water vapour shall be tested for measuring principles for which the cross sensitivity to water vapour is known.

The test shall be carried out with apparatus at room temperature. The test gas shall be a mixture containing a concentration in the range of 50 % of the measuring range of the gas to be measured and water vapour with a dew point of 55 °C. The test gas shall be applied at the tip of the flue gas probe of the apparatus for 3 min.

For example for CO_2 sensors having a cross sensitivity to water vapour the mixture 2 of Table 2 shall be applied with a concentration of water vapour as described above.

NOTE The characteristic of different measuring principles is explained in detail in EN 45544-4.

5.6 Tests with real flue gases

5.6.1 General

Tests with real flue gases are not intended, nor expected, to be reproducible in terms of specific test conditions between different test houses and times of testing. Nevertheless, they will give a reliable indication of the uncertainty of measurement for any particular apparatus.

During these tests reference analytical equipment as described in CR 1404 is to be used to record the concentrations of all relevant gases present in the flue gas even though the apparatus under test may not be capable of displaying all of them. This is required so that cross sensitivity effects can be determined.

In testing with real flue gases it is necessary to adjust the burners of the heating appliance(s) to obtain different concentrations of flue gases. A detailed description of the methodology is given in Annex B.

i) Expose the apparatus to real flue gas as described in 5.2.3 for 3 min (5 min if the apparatus is fitted with a SO_2 sensor). The readings of both the apparatus under test and the reference analytical instruments (as specified in EN 267) shall be recorded during these tests.

ii) Expose the apparatus to synthetic air, until the indication is below the detection limit listed in Table 1 (maximum 3 min, or 10 min if the apparatus is fitted with NO or SO_2 or CO high range sensor).

5.6.2 Measurement uncertainty

Measure the real flue gases exhausting from a relevant heating installation fired by the relevant fuel. The test shall be performed with the relevant burner(s) (see 5.2.3) for each type of fuel for which the apparatus is designed to be used.

In order to calculate the uncertainty in measurement of the entire apparatus, the total number of measurements shall be not less than 50, on O_2 and CO measurements at solid fuel heating installations not less than 25, distributed in roughly equal proportions between the relevant test appliances, fuels, etc. They shall be taken with real flue gas exhausting from heating installations which are fired with the fuel for which the apparatus is intended to be used in practice (as specified by the manufacturer). The concentrations measured shall cover the whole indication range relevant to the instrument being tested as shown in Table 1.

In order to achieve different relevant gas mixtures of flue gas refer to the methodology described in Annex B. The higher concentrations of NO and SO_2 may not be achievable by normal adjustments of the burners so these concentrations may be generated by injecting high concentration NO or SO_2 cylinder gases. Depending on the required concentration, the gas may be injected into the inlet air, the flue gas duct or (exceptionally) directly into the test probe.

Evaluation of the test results shall be in accordance with the ISO/IEC Guide 98-3 (GUM) and EN 60359:2002, Clause 5, using regression analysis to calculate the difference in performance between two nominally-identical specimens. This shall then be used to deduce the uncertainty in measurement, at a confidence level of 95 %, and hence measurement reproducibility compared to reference analytical equipment. For the determination of the measuring uncertainty and reproducibility, see Annex C.

5.6.3 Low temperature (applicable only to apparatus designed for outdoor use)

The complete apparatus and accessories shall be stored at a temperature of (–5 ± 2) °C for at least 2 h. The apparatus shall then be switched on and maintained at the same temperature for 10 min. On completion of the 10 min period and with the apparatus still at the same temperature, sample for 5 min from the flue of a heating appliance fitted with a natural gas burner giving a flue gas dewpoint of about 50 °C. The heating appliance chosen to generate the flue gas shall be the most demanding application relevant to the apparatus under test, as judged by the test house.

5.6.4 Stability under practical conditions

The apparatus for gaseous and/or liquid fuel shall perform 2 000 cycles, for solid fuel heating installations 400, comprising

- switch on and warm up in clean air,
- measure in flue gas for a period of 3 min at solid fuel heating installations a period of 15 min,
- measure in synthetic air for a period of 1 min, and
- switch off for an interval of at least 1 min.

Apparatus intended to be used for gaseous and/or liquid fuel and solid fuel only shall be tested according both procedures.

The heating appliance will be specified in part 2 and part 3 of the standard.

NOTE One possible source of clean air for this test could be from the flue inlet duct of a sufficiently ventilated heating appliance.

During this test, the number of measurements shall be recorded. In addition, validity of the displayed value(s) shall be checked visually at least once per day. If the apparatus incorporates a self-test function which signals failure during this test and automatically halts operation, it is permissible to manually reset the unit and continue with the test. As part of this test, the manufacturer's recommendations shall be followed regarding cleaning of dust filters, water traps, etc. On completion, immediately carry out 5.6.5 and 5.6.6.

5.6.5 Test of filter capacity

To check whether the cross-sensitivity of the CO-sensor to NO has been impaired by the previous tests, the apparatus shall be subjected to 50 ppm NO for 5 min.

5.6.6 Final test with cylinder gases

Repeat the initial performance tests as described in 5.5.3.

5.6.7 Sensor replacement (where applicable)

If the manufacturer allows the replacement of sensing element(s) by the user, the sensing element(s) shall be replaced after 5.6.6 by new element(s), in accordance with the instructions in the manual. After replacement, switch on the apparatus, allow the device to warm up and repeat 5.6.6.

5.7 Calculated values

5.7.1 General

When the instrument is fitted with facilities for calculating time weighted averages, the calculation and the results shall be tested to ensure that they conform to the specification given by the manufacturer.

5.7.2 Calculation of CO_2 gas volume ratio from O_2 measurement or vice versa

If the apparatus is equipped with a calculation of CO_2 concentration from O_2 measurement or vice versa, the calculation shall be checked with a measurement in real flue gas and with the comparison to the reference equipment. It shall be checked for oil and gas burners at three different CO_2 or O_2 concentrations.

5.7.3 CO/CO_2 ratio

When fitted with a facility for displaying the CO/CO_2 ratio, the apparatus shall be subjected to each of the test gas mixtures shown in 5.2.2.2 for 3 min.

NOTE Appropriate allowances for the practical test conditions need to be made, when evaluating CO/CO_2 ratios from measured values of O_2 or CO_2.

5.7.4 O_2 and CO on heating installations burning solid fuels

If the apparatus is intended to be used on heating installations burning solid fuels it shall do an electronic averaging of 15 min for O_2 and CO. This has to be verified.

Apply test gas 1 of 5.2.2.5, Table 5 for 10 min. and then nitrogen for 5 min.

5.8 Temperature

5.8.1 Temperature measurement (flue gas)

Adjust a suitable heat source to the reference temperatures of 133 °C, 266 °C and 400 °C, within ± 2 °C in each case. Expose the probe to the heat source for 3 min at each temperature with the apparatus energised, but the pump switched off if desired by the manufacturer.

5.8.2 Flue gas temperature response time

Expose the probe immediately to a heated air flow with a velocity of (1,5 ± 0,1) m/s and a temperature step of (+80 ± 5) °C from ambient room temperature.

5.8.3 Temperature measurement (inlet air)

Repeat the tests in 5.8.1 using temperatures of 0 °C, 25 °C and 50 °C, within ± 2 °C in each case. If the test apparatus does not display negative values, then the minimum temperature shall be (2 ± 2) °C, instead of (0 ± 2) °C.

5.8.4 Inlet air temperature response time

Expose the probe immediately to a heated air flow with a velocity of (1,5 ± 0,1) m/s and a temperature step of (30 ± 5) °C from ambient room temperature.

5.8.5 Cold start

Store the complete apparatus and accessories at (0 ± 2) °C for at least 2 h, then transfer the whole apparatus to (20 ± 2) °C and not more than 50 % RH and immediately switch on, following the manufacturer's instructions. After a further 10 min, repeat the test of 5.8.3 at 25 °C only.

5.8.6 Thermocouple compensation

If the apparatus is provided with self-compensation of the cold junction temperature of the thermocouple, store the complete apparatus and accessories at 0 °C for at least 2 h. Switch on the apparatus and place the probe in a heat source at a temperature not less than 70 °C. Transfer the whole apparatus (or the part containing the compensation circuit) except the probe, to an area of ambient temperature 30 °C.

5.8.7 High temperature

Not applicable for apparatus intended to be used only with natural gas burning, domestic appliances. In all other cases, either

a) the measuring probe shall be able to withstand a temperature above the upper limit of the measuring range (as specified by the manufacturer) for at least 30 min. Expose the probe for 30 min to a heat source of 100 °C above the upper limit of the measuring range. Leave the probe in ambient air for 10 min, then repeat the test under 5.8.1, or

b) the apparatus shall be provided with a separate permanent indicator, showing that the probe may give inaccurate readings, after being subjected to an over-range temperature.

5.9 Pressure

5.9.1 Pressure measurement (draught or circular orifice measurement)

For circular orifice appliances the differential pressure measurement accuracy in the inlet air stream of the balanced flue will be tested.

Adjust a suitable pressure source to the reference pressures of – 40 Pa, + 20 Pa and + 190 Pa, within ± 2 Pa in each case. Expose the relevant probe for 1 min at each pressure.

5.9.2 Pressure measurement (differential)

Adjust a suitable pressure source to the reference pressures of 1 000 Pa, 5 000 Pa and 9 900 Pa, within ± 200 Pa in each case. Expose the relevant probe for 1 min at each pressure.

Annex A
(informative)

Standard combustion analysis procedures

A.1 Combustion analysis in Germany

Combustion analysis of small heating appliances is covered in Germany by law in the "Federal Emission Control Act" (Small Furnaces Order – 1. BImSchV).

All appliances > 4 kW (gas and oil) or > 15 kW (solid fuels) have to be tested once per year by a chimney sweep as an official measurement.

Small appliances have to achieve flue gas heat losses lower than the values in Table A.1.

Table A.1 – Legal requirements for maximum waste gas loss

Appliance size	Installation until 31.12.1982	Installation after 1.1.1983	Installation after 1.10.1988	Installation after 1.1.1998
4 kW to 25 kW	15	14	12	11
25 kW to 50 kW	14	13	11	10
> 50 kW	13	12	10	9

Flue gas heat losses are calculated from measured oxygen content according to the relationship

$$q_A = (t_A - t_L) x \left(\frac{A2}{21 - O_2} + B \right)$$

Flue gas heat losses are calculated from measured carbon dioxide content according to the relationship

$$q_A = (t_A - t_L) x \left(\frac{A1}{CO_2} + B \right)$$

where

q_A is the flue gas heat loss, % ;[1)]

t_A is the flue gas temperature, °C;

t_L is the inlet air temperature, °C;

CO_2 is the volume ratio of carbon dioxide in the dry flue gas, %.

The parameters A1, A2 and B are taken from Table A.2.

1) Depending on the countries the abbreviations for “flue gas heat loss” and “flue gas temperature” are different.

Table A.2 – Parameters for calculation in Germany

Fuel type	Light oil	Natural gas	Town gas	Coking oven gas	Liquefied gas and LPG/air mixture
A1	0,5	0,37	0,35	0,29	0,42
A2	0,68	0,65	0,63	0,60	0,63
B	0,007	0,009	0,011	0,011	0,008

The fuel specific CO_2 max values for CO_2 calculation from O_2 -measurement are:

- natural gas 12,0 Vol. % CO_2;
- LPG 13,7 Vol. % CO_2;
- light oil 15,4 Vol. % CO_2;
- coal 18,5 Vol. % CO_2.

A.2 Combustion analysis in the United Kingdom

The following table lists current standards for combustion efficiencies of domestic gas appliances in the United Kingdom, based on dry air-free measurements.

Table A.3 – Current standards for combustion efficiencies of domestic gas appliances in the United Kingdom, based on dry air-free measurements

Appliance type	Document reference	CO limit	CO/CO_2 limit
Instantaneous water heater	BS EN 26:1998	1 000 ppm	-
Cooker – each burner – all burners	BS EN 30-1-1:1998 BS EN 30-2-1:1998	1 000 ppm 2 000 ppm	- -
Type B central heating boiler	BS EN 297:1994	1 000 ppm	-
Type C central heating boiler – normal – adverse wind	BS EN 483:1999	 1 000 ppm 2 000 ppm	 - -
Tumble dryer	BS EN 1458-1:2000 BS EN 1458-2:1999	1 000 ppm	-
Radiant convector gas fire	BS 5258-5:1989 BSI 98/708846 DC BS 6332-2:1983	- 1 000 ppm	0,02 -
Gas fire/back boiler	BS 5258-8:1980 BSI 95/717426 DC	-	0,02
Air heater/circulator	BS 5258-9:1989 BS 6332-4:1983	-	0,02
Flueless heater	BS 5258-10:1980 BS EN 449:1997	- 80 ppm at 2,1 % CO_2	0,01 -
Convector heater	BS 5258-13:1986 BS 6332-4:1983	-	0,02
Combination boiler	BS 5258-15:1990 BS EN 625:1996	-	0,02
Decorative fuel effect inset gas fire	BS 5258-16:1991 BS EN 509:2000	1 000 ppm	0,02

In addition, the major UK gas appliance servicing agency currently has a policy whereby measuring the combustion products in the flues of central heating boilers is used to indicate the need for servicing the appliance. Following extensive field measurements, the CO/CO_2 ratio of combustion gases in the secondary flue was adopted as a measure of combustion efficiency, being directly influenced by internal cleanliness, but independent of the model of appliance. A lower trigger level is used to determine the necessity for cleaning the burner, heat exchanger and primary flue. After cleaning, an upper trigger level is used to assess whether the appliance is safe to be left for another year. If the reading is above this level, then action must be taken to reduce the CO/CO_2 ratio. The values determined for the lower and upper trigger levels were 0,004 and 0,008, respectively.

A.3 Combustion analysis in Italy

Combustion analysis in Italy is requested by law 10/1991 and regulated by decree 421/93, as modified by DPR 551/1999, only for appliances included in heating plants, with power > 4 kW and supplied with gas or liquid fuel. They have to achieve a combustion efficiency not lower than the values in Table A.4.

Table A.4 – Legal requirements for combustion efficiency η in Italy

Appliance power P kW	Heating plants with water as heat carrier		Heating plants with air as heat carrier	
	Installation until 29.10.1993	Installation after 29.10.1993	Installation until 29.10.1993	Installation after 29.10.1993
4 < P < 400	η ≥ (84 + 2 log P) - 3	η ≥ (84 + 2 log P)	η ≥ (83 + 2 log P) - 6	η ≥ (83 + 2 log P) - 3
P ≥ 400	η ≥ (84 + 2 log 400) - 3	η ≥ (84 + 2 log 400)	η ≥ (83 + 2 log 400) - 6	η ≥ (83 + 2 log 400) - 3

An official inspector tests the appliances, as follows:

- every two years, if P ≤ 35;
- every year, if 35 < power ≤ 350;
- every six months, if power > 350.

The procedure of on-field test by the official inspector is reported in Italian Standard UNI 10389.

The calculation formula for combustion efficiency is

- η = 100 – Q_s where Q_s = flue gas heat loss
- Q_s is calculated from the measured oxygen content, according to the relationship:

$$Q_s = (T_f - T_a) * [A_1 / (21-O_2) + B]$$

- Q_s is calculated from the measured carbon dioxide content, according to the relationship:

$$Q_s = (T_f - T_a) * (A_2 / CO_2 + B)$$

- T_f = flue gas temperature (°C),
- T_a = combustion air temperature (°C),
- O_2 = volume ratio of oxygen in the dry flue gas (%),
- CO_2 = volume ratio of carbon dioxide in the dry flue gas (%).

The parameters A_1, A_2 and B are taken from Table A.5.

Table A.5 – Parameters for heat loss calculation in Italy (reference UNI 10389)

Fuel	Natural gas	LPG	Light fuel oil	Heavy fuel oil
A_1	0,66	0,63	0,68	0,68
A_2	0,38	0,42	0,50	0,52
B	0,010	0,008	0,007	0,007

In all appliances burning gaseous or liquid fuel, the higher concentration of carbon monoxide allowed in the flue gas is 1 000 ppm (based on dry air-free measurements). In all appliances burning liquid fuels, the measured smoke spot number shall be < 2 for light fuel oil and < 6 for heavy fuel oil.

The fuel-specific maximum CO_2 values for the fuels distributed in Italy are indicated in UNI 10389, as

- natural gas 11,7 Vol. % CO_2,
- LPG 13,9 Vol. % CO_2,
- light fuel oil 15,1 Vol. % CO_2,
- heavy fuel oil 15,7 Vol. % CO_2.

A.4 Combustion analysis in Switzerland

A.4.1 General

The use of “Portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances” is legally regulated [2)] only for official measurements (inspections) on domestic appliances run on “extra light” fuel oil or natural gas.

A.4.2 Combustion installations run on “extra light” fuel oil

a) The flue gas losses from heating boilers with forced draught burners shall not exceed the following limits:

   1) with single stage burner operation 7 %;

   2) with two-stage burner operation

      i) during operation of first burner stage 6 %,

      ii) during operation of second burner stage 8 %.

b) In the case of heating boilers with oil vaporization burners, the limit indicated on the type-approval plate for the permitted flue gas losses shall not be exceeded.

c) The limits for flue gas losses laid down in paragraphs a) and b) shall apply to installations which are marketed after 31 December 1992.

d) The authorities may lay down less stringent limits in the case of heating boilers where the temperature of the heat carrier fluid is over 110 °C and where the requirements laid down in paragraph a) cannot be complied with because technology and operating conditions do not allow or because it is economically unacceptable.

e) In the case of heating boilers with forced draught burners where the temperature of the water is no more than 110 °C and which are marketed before 1 January 1993, the flue gas losses shall not exceed the following limits:

   1) installations with a heat input of up to 70 kW 10 %;

---

2) Ordinance on air pollution control (RS 814.318.142.1).

2) installations with a heat input of over 70 kW 9 %.

A.4.3 Gas combustion installations

a) In the case of heating boilers with forced draught burners run on gas fuels, the flue gas losses shall not exceed the following limits:

1) with single stage burner operation 7 %;

2) with two-stage burner operation

i) during operation of first burner stage 6 %,

ii) during operation of second burner stage 8 %.

b) The limits for flue gas losses laid down in paragraph a) shall apply to installations which were marketed before 31 December 1992.

c) The authorities may lay down less stringent limits in the case of heating boilers where the temperature of the heat carrier fluid is over 110 °C and where the requirements laid down in paragraph a) cannot be complied with because technology and operating conditions do not allow or because it is economically unacceptable.

d) In the case of heating boilers with forced draught burners run on gas fuels where the temperature of the water is not more than 110 °C and which are marketed before 1 January 1993, the flue gas losses shall not exceed the following limits:

1) installations with a heat input of up to 70 kW 10 %;

2) installations with a heat input of over 70 kW 9 %.

e) In the case of heating boilers and circulation heaters with atmospheric gas burners and with a heat input of up to 350 kW, where water is used as the heat carrier and the temperature of the water is no more than 110 °C, the flue gas losses shall not exceed the following limits:

1) for installations marketed after 31 December 1992, the q_A limit indicated on the type-approval plate;

2) for all other installations, the limit q_A = 14,5 - 2 log Q_{Nmax}, but no more than 12,5 %.

where

q_A = limit for the maximum permitted flue gas losses in percent (%);

log Q_{Nmax} = logarithmic value of the maximum boiler nominal output in kW.

f) The requirements laid down for forced draught burners shall apply to heating boilers and circulation heaters with atmospheric gas burners with a heat input of over 350 kW.

A.4.4 Calculation of flue gas losses

The flue gas losses are calculated using the following equation:

$$q_A = (t_A - t_L) \times \left\{ \frac{A}{21 - O_2} + B \right\}$$

where

q_A = flue gas loss in %;

t_A = flue gas temperature in °C;

t_L = combustion air temperature in °C;

O_2 = volume content of oxygen in the dry flue gas given in %;

A, B = constants having the values:
for “extra light” fuel oil: A = 0,68, B = 0,007
for natural gas: A = 0,66, B = 0,009.

A.5 Combustion analysis — generic

For countries where no national regulations apply these generic methods should be considered.

Combustion analysis is described in detail in EN 15378:2007, Annex C, C.1.1 to C.1.3 and C.3.

Annex B
(normative)

Real flue gas measurements – Methodology and test methods

The content of CO, NO and SO_2 in a specific flue gas depends mainly on the air/fuel ratio of a burner installation. The level is altered by using, for example, gas or light oil, and typical curves are shown in Figure B.1. Optimum combustion quality performance is reached, depending on the type of heating appliance and burner being used, at an air ratio of Lambda > 1,0 (O_2 = 0 %, CO_2 = max. value). At an air ratio of Lambda = 1,2, for example, the CO level is a minimum and the NO a maximum. Depending on the combustion process, the amount of CO will increase when changing the heating appliance adjustment either to air deficiency or to excess air. At the same time, the amount of NO will decrease. The formation of hydrogen will increase mainly under air deficiency conditions, while hydrocarbons will increase in the same way as CO at a lower level of air ratio.

Tests with real flue gases are not intended, nor expected, to be reproducible in terms of specific test conditions between different test houses and times of testing. Nevertheless, they will give a reliable indication of the uncertainty of measurement for any particular apparatus. To achieve different relevant gas mixtures of flue gas (i.e. concentrations of O_2, CO_2, CO, NO and SO_2) the air ratio shall be changed, by varying the amounts of

– combustion air to the burner,

– fuel to the burner, and/or

– flue gas draught.

To obtain a representative result for the analytic function and reproducibility (see EN 60359:2002, Annex C and Clause 5) the measuring points shall be distributed over the whole indication range. To achieve this, the indication range is divided into 10 equal sections, each with a range of ± 5 % of the indication range, and with a minimum number of measuring points in each section, as defined in Table B.1. The remaining measuring points are performed at the most relevant ranges, depending on the applications for which the device is designed to be used.

Table B.1 – Minimum numbers of measurements

Percentage of the range (± 5 %):	5	15	25	35	45	55	65	75	85	95	Total	Remainder
For CO, NO, SO_2:	2	2	2	2	2	2	2	2	2	2	20	30
For O_2:	5	5	5	5	5	3	3	3	3	3	40	10
For CO_2:	3	3	3	3	3	5	5	5	5	5	40	10

Before starting the tests, the reference analytical equipment (described in EN 267, EN 676 and CR 1404) shall be calibrated with the test gases as specified in 5.2.2. In order to determine the cross-sensitivity of a test parameter, the heating appliance shall be set up over the whole range of the air ratio within the measuring range of the relevant parameter.

Each measurement shall be set up as follows:

– a suitable test probe (with a sufficient number of connections) for the reference analytical instrument and the apparatus on test shall be used to ensure the same sampling of flue gas concentration to the instruments;

– the heating appliance shall be adjusted to the intended concentration of the test parameter (O_2, CO_2, CO, NO or SO_2);

– the actual concentration shall be verified by the reference analytical instrument. When a constant reading of values is obtained, but at least after 3 min (5 min for SO_2 sensor), the concentration measured by the reference analytical instrument and the test apparatus shall be recorded at the same time.

At any measurement of the parameters of CO, NO or SO_2 the air ratio shall be recorded. The levels of O_2 or CO_2 and CO shall also be recorded in order to evaluate the combustion performance.

Because the higher concentrations of NO and SO_2 may not be achieved by normal adjustments of the burners, these concentrations may be generated by injecting high concentration NO or SO_2 test gases from cylinders. Depending on the required concentration, the gas may be injected into the inlet air, the flue gas duct or (exceptionally) directly into the test probe.

In case of fluctuating flue gas volume ratios for CO, which is common in the high range of CO (up to 20 000 ppm), a sufficient quantity of the flue gas sample shall be extracted into a suitable gas bag to achieve a stable values for carrying out the tests. A measurement shall be carried out with the gas mixture from this bag supplied to the apparatus and the reference analytical instruments via the same test probe.

This diagram shows characteristic values for a typical light oil burner and a typical natural gas burner. It is included for information only, and shall not be used for reference purposes.

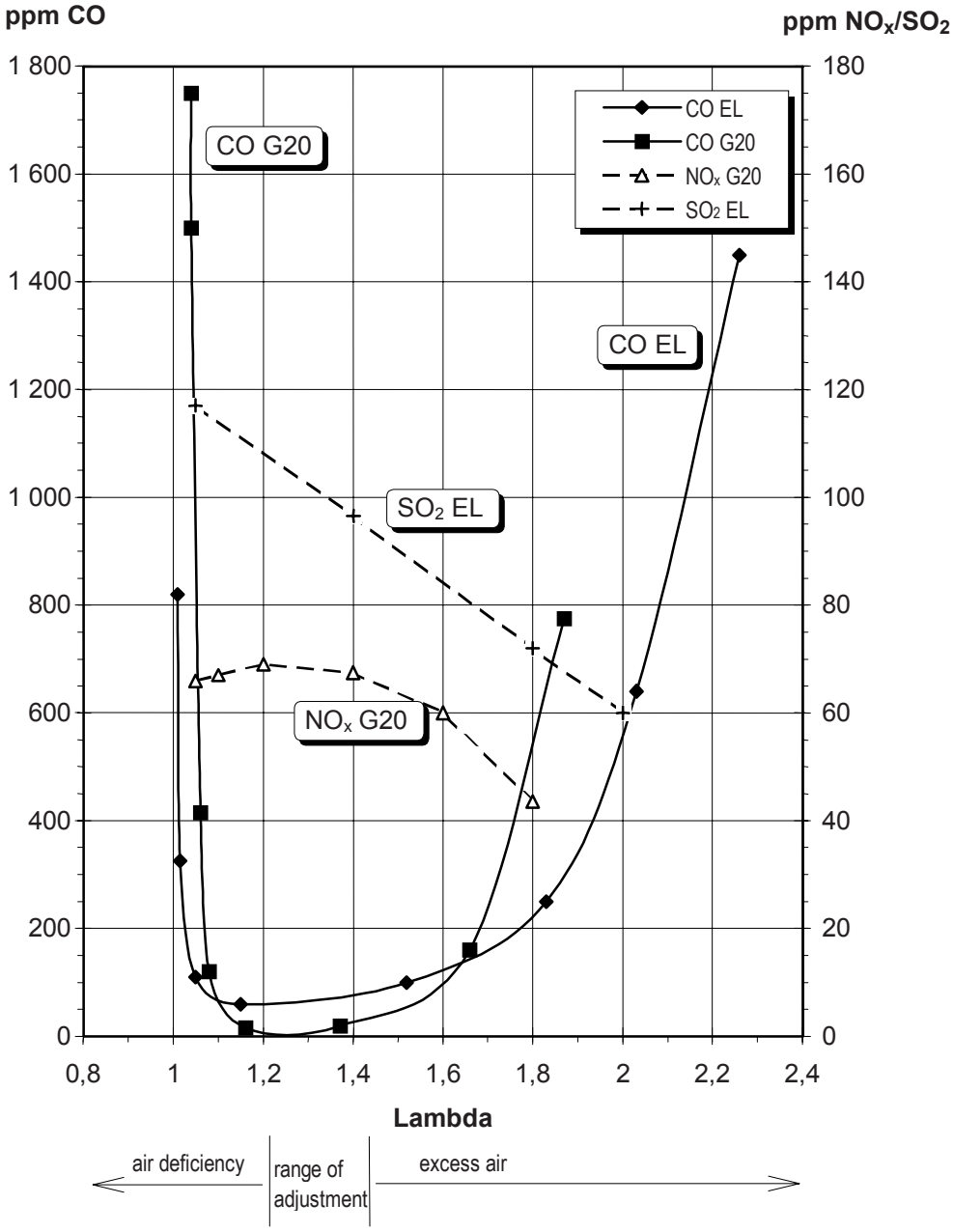

Figure B.1 – CO, NO_x and SO_2 variation with air ratio

Annex C
(normative)

Standard methods for determining measuring uncertainty

C.1 Determination of the analytic function

The analytic function between the reference measuring method (y_i) and the test specimen (x_i) shall be determined from 50 pairs of variables, as described in the ISO/IEC Guide 98-3 (GUM), Appendix H.3.

The measuring apparatus shall meet the requirements on uncertainty over the entire indication range.

C.2 Determination of reproducibility

The standard deviation between two measuring devices, when measuring an unknown quantity of the subject of the test, shall be determined using double determinations. The concentrations of the subject of the test in the waste gas shall be displayed on two identical measuring devices simultaneously.

The standard deviation S_D shall be calculated in accordance with the following formula:

$$S_D = \pm\sqrt{\frac{\sum_{i=1}^{n}(x_{1i} - x_{2i})^2}{2n}}$$

where

$x_{1,2}$ = measured values;

n = number of double determinations.

The multiplication of the standard deviation with the factor t = 1,98 for $2n \geq 100$ produces the uncertainty range U with a statistical certainty of 95 %, from which the reproducibility R is calculated using the following formulae:

$$U = t \times S_D$$

$$R = \frac{x_{max}}{U} = \frac{x_{max}}{t \times S_D}$$

where

x_{max} is the upper limit of measuring range.

Bibliography

EN 15378:2007, *Heating systems in buildings – Inspection of boilers and heating systems*

EN 45544-4, *Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours – Part 4: Guide for selection, installation, use and maintenance*

EN 60079-29-1, *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases (IEC 60079-29-1)*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™