



BSI Standards Publication

Carbon monoxide in dwellings and other premises and the combustion performance of gas-fired appliances

Part 5: Guide for using electronic portable combustion gas analysers in non-domestic premises for the measurement of carbon monoxide and carbon dioxide levels and the determination of combustion performance

Publishing and copyright information

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 September 2010. It was prepared by Technical Committee GSE/30, *Gas installations (1st, 2nd and 3rd family gases)*. A list of organizations represented on this committee can be obtained on request.

Relationship with other publications

The standard is issued in five parts:

- Part 1: *Guide for identifying and managing sources of fumes, smells, spillage/leakage of combustion products and carbon monoxide detector activation;*
- Part 2: *Guide for using electronic portable combustion gas analysers in the measurement of carbon monoxide and the determination of combustion performance;*
- Part 3: *Guide for responding to measurements obtained from electronic portable combustion gas analysers;*
- Part 4: *Guide for using electronic portable combustion gas analysers as part of the process of servicing and maintenance of gas-fired appliances;*
- Part 5: *Guide for using electronic portable combustion gas analysers in non-domestic premises for the measurement of carbon monoxide and carbon dioxide levels and the determination of combustion performance.*

Information about this document

The presentation of guidance in this standard is intended to help operatives when using electronic portable carbon monoxide (CO) and carbon dioxide (CO₂) analysers. Its aim is to help them consider relevant issues and circumstances in non-domestic premises relating to:

- the identification and assessment of combustion products in indoor air;
- the determination of the ratio of combustion products from gas-fired appliances;
- how to respond to the measurements obtained from electronic portable combustion gas analysers.

It is not intended to be an exhaustive step-by-step procedure and individual cases need to be judged accordingly.

Use of this document

As a guide, this part of BS 7967 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

This British Standard allows gas appliance manufacturers' instructions to recommend acceptable CO/CO₂ ratios or CO/CO₂ readings that differ from those recommended in this standard, where stated. Use of manufacturers' recommendations is allowed only where it will result in at least an equivalent level of safety. In such circumstances, it is important that the manufacturer's instructions are followed.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

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

Attention is drawn to the following statutory regulations.

- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) [1]
- Gas Safety (Management) Regulations 1996 (GSMR) [2]
- Gas Safety (Installation and Use) Regulations 1998 (GSIUR) [5]
- Gas Safety (Application) Order (Isle of Man) 1996 [7]
- Gas Safety (Installation and Use) Regulations (Northern Ireland) 2004 [8]
- Health and Safety (Gas) (Guernsey) Ordinance 2006 [9]
- The Control of Substance Hazardous to Health Regulations 2002 (COSHH) [12]
- Health and Safety at Work etc. Act 1974 (HSWA) [15]
- Clean Air Act 1993 [19]

1 Scope

This standard gives guidance for identifying and investigating spillage, leakage or build-up of combustion products from gas-fired appliances in non-domestic premises. It gives recommendations for determining the combustion performance of such equipment, using electronic portable combustion gas analysers. This involves sampling and measuring the carbon monoxide (CO) and carbon dioxide (CO₂) in the ambient air and in gas-fired appliance chimneys.

This standard is for use with equipment using 1st, 2nd or 3rd family gases.

NOTE 1 An operative attending non-domestic premises might be required to examine standard gas-fired appliances which are domestic or commercial as well as customized process plant/equipment.

NOTE 2 This standard does not cover the response of an emergency service provider (ESP) to a gas emergency. It also does not cover procedures for investigating incidents that are reportable under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) [1] and the Gas Safety (Management) Regulations 1996 (GSMR) [2].

NOTE 3 Combustion products from gas-fired appliances contain aldehydes and oxides of nitrogen (NO_x), predominantly nitrogen monoxide (nitric oxide, NO) and nitrogen dioxide (NO₂). Although this standard does not cover the measurement of these substances, quantities of such products could be present in the air and could cause harm and irritation to humans. For guidance on the health considerations associated with these combustion products, see the Institute for Environment and Health assessment, Indoor air quality in the home: Nitrogen dioxide, formaldehyde, volatile organic compounds, house dust mites, fungi and bacteria [3].

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies.

BS 5440-1:2008, *Flueing and ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases) – Part 1: Specification for installation of gas appliances to chimneys and for maintenance of chimneys*

BS 6172, *Installation and maintenance of domestic gas cooking appliances (2nd and 3rd family gases) – Specification*

BS 7967-1, *Carbon monoxide in dwellings and the combustion performance of gas-fired appliances – Part 1: Guide for identifying and managing sources of fumes, smells, spillage/leakage of combustion products and carbon monoxide detector activation*

BS 7967-2:2005, *Carbon monoxide in dwellings and the combustion performance of gas-fired appliances – Part 2: Guide for using electronic portable combustion gas analysers in the measurement of carbon monoxide and the determination of combustion performance*

BS 7967-3, *Carbon monoxide in dwellings and the combustion performance of gas-fired appliances – Part 3: Guide for responding to measurements obtained from electronic portable combustion gas analysers*

BS 7967-4, *Carbon monoxide in dwellings and the combustion performance of gas-fired appliances – Part 4: Guide for using electronic portable combustion gas analysers as part of the process of servicing and maintenance of gas-fired appliances*

BS 8494, *Electronic portable and transportable apparatus designed to detect and measure carbon dioxide in indoor ambient air – Requirements and test methods*

BS EN 45544 (all parts), *Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours*

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

GAS SAFE REGISTER. Technical Bulletin 001. *The gas industry unsafe situations procedure*. Sixth edition. Basingstoke: Capita Gas Registration and Ancillary Services Ltd, 2009 [11]

3 Terms and definitions

For the purposes of this British Standard the following terms and definitions apply.

3.1 ambient air

atmosphere surrounding the equipment

NOTE The concentration of CO₂ in ambient air within premises is typically different from the concentration of CO₂ in outdoor air.

3.2 chimney

structure consisting of a wall or walls enclosing a flue or flues

NOTE This includes chimneys of all materials (e.g. metal, masonry, plastic). It may be either an open-flued chimney for use with an open-flued appliance or a room-sealed chimney configuration for use with a room-sealed appliance.

3.3 closed flue (Type B2)

flue system that is closed in a room or internal space

NOTE This is due to the absence of a draught diverter, flue break or draught break within a chimney. It is now referred to as an “open flue without a draught diverter”.

3.4 combustion performance

measurements of carbon monoxide, carbon dioxide and oxygen that are indicators of the quality of combustion in a gas-fired appliance

NOTE A common approach is to use the ratio (CO/CO₂) although some equipment manufacturers might use specific flue gas concentrations of CO₂ and O₂ in order to optimize gas combustion.

3.5 customer-adjustable ventilation (manual/mechanical)

adjustable purpose-provided unit or assembly designed to allow ventilation

3.6 electronic portable combustion gas analyser

electronic equipment that can be carried around easily and that detects and measures the presence of combustion gases, clearly displaying the result

- 3.7 emergency service provider (ESP)**
person(s) acting to prevent an escape of gas on behalf of a gas transporter
- 3.8 flue**
passage for conveying combustion products to the outside air
- 3.9 flueless gas-fired appliance (Type A)**
gas-fired appliance not intended for connection to a chimney or to a device for directing the combustion products to the outside of the room in which the gas-fired appliance is installed
- 3.10 gas concentration**
amount of CO and/or CO₂ registered as parts per million (ppm) or percent by volume
- 3.11 gas-fired appliance**
gas appliance or plant using 1st, 2nd or 3rd family gases and operating in non-domestic premises
- 3.12 mechanical extraction/ventilation (MEV)**
forced extraction/ventilation systems
- 3.13 non-domestic premises**
units of property open to members of the public or employees working within the establishment
- NOTE These include schools, hotels, guest houses, restaurants, kitchens, canteens, laundries, laundrettes, shops, offices, leisure centres/facilities, churches, meeting halls, factories, waiting rooms and agricultural premises. These property units can be temporary or non-temporary.*
- 3.14 operative**
person carrying out gas work
- 3.15 occupancy**
number of people occupying an indoor space
- 3.16 open-flued gas-fired appliance (Type B)**
gas-fired appliance designed to be connected to an open flue chimney system that directs combustion products to outside air
- NOTE The combustion air is drawn directly from the room or space containing the gas-fired appliance.*
- 3.17 permanent ventilation**
non-adjustable unit or assembly designed to ventilate a room or space
- 3.18 responsible person**
person able to authorize work to be undertaken
- NOTE This might be an employee of the company using the premises, or the owner of the premises.*
- 3.19 risk assessment**
evaluation of health and safety aspects of a gas-fired appliance carried out using an established or specified format
- NOTE See the Health and Safety Executive (HSE) guide, Five steps to risk assessment [4], for further information.*

3.20 room-sealed gas-fired appliance (Type C)

gas-fired appliance containing a combustion circuit sealed within the room in which the gas-fired appliance is installed

NOTE A combustion circuit consists of an air supply, combustion chamber, heat exchanger and re-direction of the combustion products.

3.21 suspect gas-fired appliance

gas-fired appliance which might be a source of excessive levels of CO and/or CO₂

3.22 work

installation, maintenance, servicing, removal, permanent adjustment, repair, changing the position, alteration or renewal of a gas fitting or purging it of air or gas

NOTE This term is consistent with the definition given in Regulation 2 of the Gas Safety (Installation and Use) Regulations (GSIUR) 1998 [5]. Guidance on Regulation 2 is contained in the Health and Safety Commission Approved Code of Practice and Guidance, Safety in the installation and use of gas systems and appliances [6].

4 Competency

Persons carrying out any gas installation, commissioning, servicing and/or maintenance work shall be competent to do so.

COMMENTARY AND RECOMMENDATIONS ON 4

It is a statutory requirement that all gas work be carried out by a business or self-employed person(s) that is a member of a "class of persons" registered with a registration body which has been approved by an approval body to operate and maintain such a register.

The statutory regulations, registration bodies and approval bodies applicable to Great Britain, the Isle of Man, Northern Ireland and Guernsey are given in Table 1.

The qualifications which persons need to have to be deemed competent to carry out gas work are given in Table 2.

Table 1 Registration and approval bodies by country/territory

Country/territory	Gas registration body	Approval body	Statutory regulations
Great Britain	Gas Safe Register	Health and Safety Executive (HSE)	Gas Safety (Installation and Use) Regulations 1998 [5]
Isle of Man	Gas Safe Register	Health and Safety at Work Inspectorate (HSWI)	Gas Safety (Installation and Use) Regulations 1994, as amended and applied by the Gas Safety (Application) Order 1996 [7]
Northern Ireland	Gas Safe Register	Health and Safety Executive Northern Ireland (HSENI)	Gas Safety (Installation and Use) (Northern Ireland) Regulations 2004 [8]
Guernsey	Gas Safe Register	Health and Safety Executive for the States of Guernsey [HSE (Guernsey)]	Health and Safety (Gas) (Guernsey) Ordinance 2006 [9]

Table 2 Competence requirements by country/territory

Qualifications	Great Britain and Isle of Man	Northern Ireland	Guernsey
Current certificate(s) of competence in the type of gas work to be conducted, issued by an awarding body accredited by the United Kingdom Accreditation Service (UKAS) (ACS certification)	✓	✓	✓
National/Scottish Vocational Qualification (N/SVQ accredited by Ofqual), which is aligned in matters of gas safety	✓	✓	✓
National/Scottish Vocational Qualification (N/SVQ accredited by Ofqual), which is aligned under the HSC ACoP arrangement ^{A)} as approved with the registration body	✓	✓	✗
Any other scheme recognized by the gas registration body for registration purposes	✓	✓	✓

^{A)} *Health and Safety Commission's Approved Code of Practice (ACoP) (COP20) – Standards of training in safe gas installation [10].*

5 Safety principles

5.1 Basic principles

Operatives investigating suspected or actual combustion products in ambient air should adhere to the following basic principles:

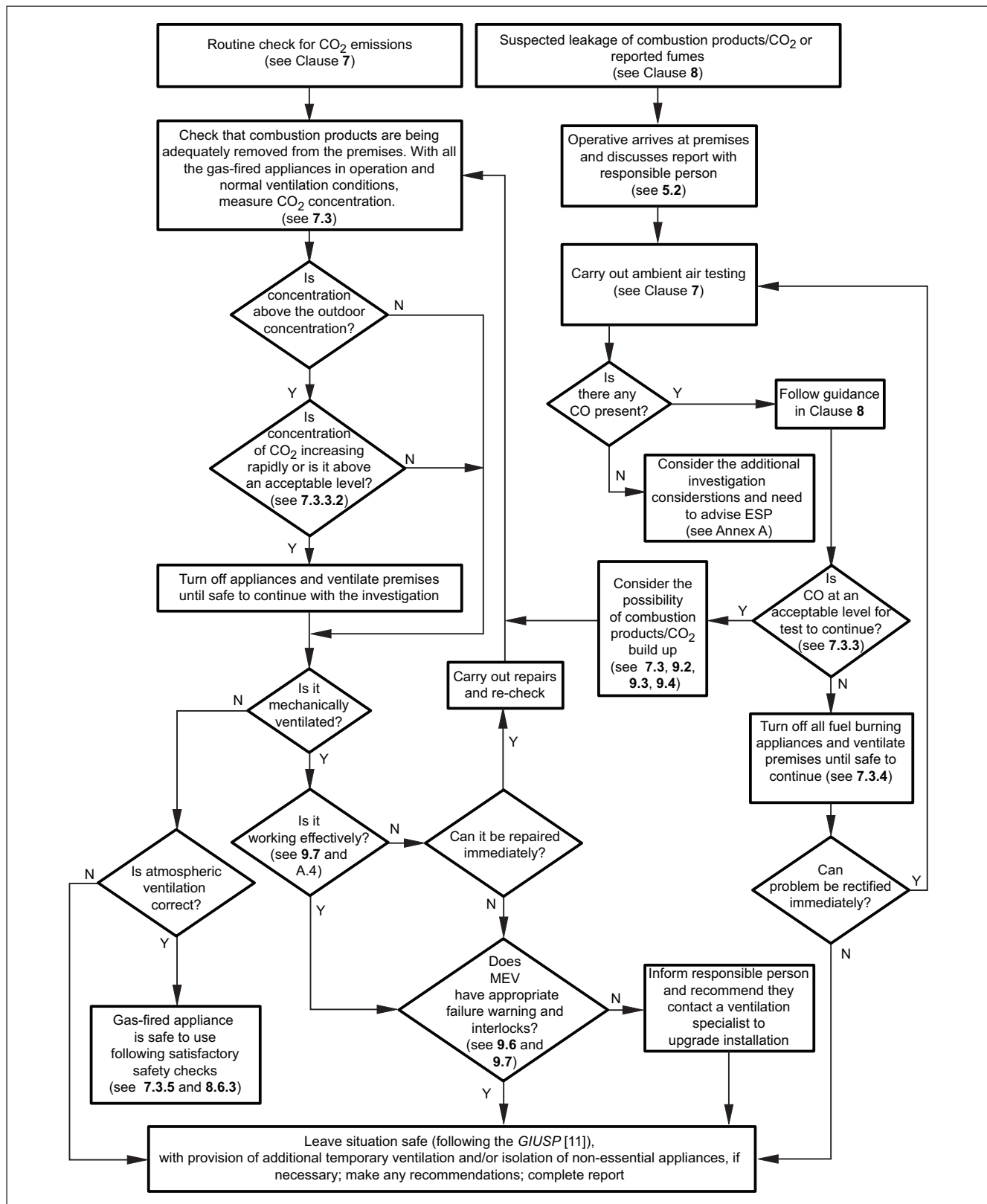
- to protect life;
- to protect property;
- to locate fuel-burning appliances;
- to locate any escape of gas, fumes, smells or spillage/leakage of combustion products;
- to confirm the safe installation and operation of gas-fired appliances;
- to advise the responsible person of required remedial action; and
- to complete the necessary reports, documentation and actions in accordance with the Gas Industry Unsafe Situations Procedure (GIUSP) [11].

5.2 Liaising with the responsible person

5.2.1 The assistance of the responsible person on site should be sought, wherever practicable, so that investigations proceed safely and thoroughly.

NOTE See Figure 1 for a flowchart of the procedure for routine investigations for CO₂ emissions and investigations regarding suspected leakage of combustion products from gas-fired appliances.

Figure 1 Procedure for routine checks for CO₂ emissions and the suspected leakage of combustion products/CO₂ or reported fumes



5.2.2 When liaising with the responsible person, the following questions should be asked.

- Does the problem only occur when a gas-fired appliance (including mobile or portable appliances) is or has been in use? Are there any safety or warning notices or labels attached to the gas-fired appliance?
- Do people feel unwell in the premises and recover when outside or away from the workplace? What are their symptoms? How many people are normally around this area?
- Is there a pattern to the problem occurring? For example has it been observed once, more than once or many times? Does it occur during particular weather conditions, certain activities, from the use of a particular chemical or substance or in a particular area?
- Are there unusual conditions within the premises? For example, is there excessive heat, condensation on the windows and cold surfaces, or a build-up of smells?

5.2.3 Other issues that could be discussed with the responsible person include:

- a) the identification of any direct-fired equipment;
- b) any recently installed equipment/building modifications;
- c) any flueless gas-fired appliances;
- d) the gas-fired appliance maintenance history (e.g. flueing problems, re-entry issues);
- e) the likelihood that the gas-fired appliances have been misused; and
- f) any operating difficulties.

5.3 Operative judgement

The operative should exercise judgement when deciding which specific tests and checks are relevant to the particular circumstances of a gas-fired appliance or site investigation. This judgement should be based upon all available information (written and verbal) and made with the co-operation of the responsible person on site (see commentary on 5.4).

5.4 Risk assessment

The results of readings and tests carried out by the operative might identify a gas safety risk or a suspect or dangerous gas-fired appliance that for reasons of safety or severe business risk cannot be turned off or disconnected. In this instance, the operative should request that the responsible person completes a documented risk assessment to determine a safe course of action, identify and implement necessary remedial works or determine a temporary safe system of work.

In all cases the operative should keep accurate records of completed tests, checks and any actions they have carried out as a result of the risk assessment. This should include times, dates and descriptions signed by the operative and the responsible person.

The risk assessment might conclude that a suspect gas-fired appliance can remain in use provided that additional safety measures are put in place. Such additional safety measures might include the evacuation of a particular area, additional ventilation/extraction of combustion

gases, a permit-to-work system before access to a particular area is permitted, or the close monitoring of exposure times and levels.

COMMENTARY ON 5.4

The responsible person is likely to have expert knowledge of site processes, company procedures and safety controls, and is likely to have access to manufacturer's guidance and the relevant industry standards. They are therefore in a good position to carry out a risk assessment and take into account the process risk, or risk to the business from the actions proposed by the operative.

It would be an immediate health and safety risk to shut down certain industrial processes. For instance some furnaces need to be shut down gradually and cooled over a number of days to prevent the furnace from collapsing. This is the case for some glass-producing processes that utilize tanks of molten tin to float the cooling glass. An immediate shut down of an industrial process or large gas installation could produce its own risks from loss of gas pressure in the system that might require complex testing and purging procedures to re-instate.

In the case of hospitals and care homes, the loss of heating and/or hot water facilities could result in the evacuation of vulnerable people and the involvement of emergency agencies.

In addition to the health and safety risk, the shut down of an industrial process could result in major financial losses for the business.

5.5 Death or major injury

Where an operative becomes involved in a situation where death or major injury has occurred, they should abstain from any work until after the emergency services have carried out any necessary actions. They should then ascertain whether the HSE is aware of the situation and if so, whether it has completed its enquiries. Work to rectify any faults should not be carried out until the HSE has completed its investigation.

NOTE When death or major injury (i.e. loss of consciousness or acute illness requiring medical treatment) has occurred, it is the duty of the person deemed responsible for the premises (i.e. the employer of any injured person or the person having control of the premises at the time) to report the incident to the HSE and complete an appropriate RIDDOR report [1].

6 Electronic portable combustion gas analysers

COMMENTARY ON CLAUSE 6

Electronic portable combustion gas analysers extract a continuous sample of combustion products. They dry and filter the sample, measuring, calculating and displaying CO and CO₂ concentration levels before expelling it from the analyser.

6.1 Type

6.1.1 General

Electronic portable combustion gas analysers should conform to either BS EN 50379-3 or BS 8494.

NOTE BS EN 50379-3 superseded BS 7927:1998 including Amendment 1:1999, Heating appliances for domestic applications – Portable apparatus designed to detect and measure specific combustion

flue gas products – Requirements, on 1 March 2007. However, electronic portable combustion gas analysers conforming to BS 7927:1998 including Amendment 1 remain acceptable for the purposes of this standard.

6.1.2 Electronic portable combustion gas analysers conforming to BS EN 50379-3

Electronic portable combustion gas analysers that conform to BS EN 50379-3 have the following characteristics:

- a) they are identified by a durable label on the analyser;
- b) they are hand held or portable, with a display and keypad for information and control;
- c) they are battery and/or mains powered and have an automatic pump;
- d) they use an external probe to extract combustion products from a sample point for measurement and calculation within the analyser;
- e) they use a filter/water trap to remove particles and water vapour from the combustion products sample;
- f) they measure the oxygen (O₂) and CO concentration in a sample of combustion products drawn from the chimney/flue system; and
- g) they measure or calculate the CO₂ concentration and CO/CO₂ ratio in a sample of combustion products.

6.1.3 Electronic portable combustion gas analysers conforming to BS 8494

Electronic portable gas analysers that conform to BS 8494 have the following characteristics:

- a) they are identified by a durable label on the analyser;
- b) they are hand held or portable, with a display using characters not less than 8 mm high (unless the display is backlit);
- c) they are battery powered and have an automatic pump;
- d) they use probes and sensors constructed from materials that are not affected by substances found in the environment of its intended use;
- e) they are constructed to prevent damage to sensors and pumps from particulate matter and liquids that might be expected in its application; and
- f) they measure concentrations of CO₂ in indoor ambient air.

NOTE Electronic portable combustion analysers conforming to BS 8494 that read CO₂ in ambient air only do not fully meet the complete instrumentation requirements outlined in BS 7967-1, BS 7967-2, BS 7967-3 and BS 7967-4 where measurements of CO₂ in flue gases are required.

6.2 Selecting a gas analyser for measuring levels of CO in ambient air

To measure CO levels in ambient air in non-domestic premises, the electronic portable combustion gas analyser can be of a type that directly measures CO or of a type that directly measures CO and O₂.

NOTE 1 Electronic portable combustion gas analysers of the type that directly measure CO and O₂ calculate a CO₂ concentration from the O₂ measurement obtained from the flue gases.

The accuracy of the electronic portable combustion gas analysers used in the measurement of CO should be within ± 3 ppm of the instrument reading for readings at or below 20 ppm, and within $\pm 5\%$ for readings over 20 ppm. The manufacturer's written specification should always be checked to confirm that the electronic portable combustion gas analyser is accurate to these levels. The electronic portable combustion gas analyser used should measure and display CO in ppm.

NOTE 2 It is recommended that an electronic portable gas analyser used to measure levels of CO in ambient air conforms to BS EN 50379-3.

NOTE 3 Not all electronic portable combustion gas analysers can record the maximum CO reading; some only display the current level. In the latter instance it is necessary to exercise extra vigilance to prevent a peak value from passing unobserved. It is important to consider this when selecting an electronic portable combustion gas analyser.

6.3 Selecting a gas analyser for measuring levels of CO₂ in ambient air

To detect the presence of CO₂ in non-domestic premises, electronic portable combustion analysers that directly measure CO₂ in ambient air should conform to BS 8494.

Electronic portable combustion gas analysers can indicate gas concentrations of CO₂ across a range of at least 0 ppm to 5 000 ppm with a resolution of 50 ppm or higher; or across a range of 5 000 ppm to 20 000 ppm with a resolution of 2% of the displayed reading or higher.

Electronic portable combustion gas analysers with a range of 0 ppm to 5 000 ppm may be considered suitable when, for example, monitoring indoor air quality or measuring CO₂ concentrations in commercial laundry and kitchen environments.

Electronic portable combustion gas analysers with a range of 5 000 ppm to 20 000 ppm may be considered suitable when, for example, assessing the safe operation of open-flued appliances installed in compartments.

CO and CO₂ detectors conforming to BS EN 45544 (all parts), which detect gas concentration and alert an operator to unsafe workplace ambient air, should not be used as combustion gas analysers or ambient air analysers.

6.4 Use and maintenance

6.4.1 Electronic portable combustion gas analysers should be carefully used and maintained in accordance with the manufacturer's instructions. Before using the analyser it is essential that operator manuals are read.

NOTE Refer to the GIUSP [11] for further information.

6.4.2 The electronic portable combustion gas analyser should also be checked for the following.

- a) Correctly inserted batteries that are charged and not leaking.
- b) Current proof of calibration.

- c) A correctly functioning display.
- d) That it is set to zero and has been purged in accordance with the manufacturer's instructions.
- e) A working pump.
- f) Clean and dry filters and water traps.
- g) A probe tubing that is free from leaks or damage.
- h) Correctly connected sample lines and probes.

NOTE Some electronic portable combustion gas analysers when sampling for CO₂ also need to be set to the relevant fuel used by the gas-fired appliance being tested.

6.4.3 Electronic portable combustion gas analysers should not be used to measure the leakage of combustion products from the gas appliance combustion circuit except where their use for this purpose is detailed in the manufacturer's instructions.

6.4.4 As electronic portable combustion gas analysers can give a false reading if the sensor fails, a check should be carried out before use by measuring combustion products from open-flame equipment. Where a false reading is suspected, the operative should contact the gas analyser manufacturer for advice on how to check instrumentation on site.

7 Measuring levels of CO and CO₂ in ambient air

7.1 General

Normally, the increase in CO and CO₂ levels in ambient air is only measured to check that a gas-fired appliance has been installed and is operating correctly, in accordance with the manufacturer's instructions.

CO has a significantly higher toxicity than CO₂. However, excessive levels of CO₂ in the air can be a pre-cursor to a significant rise in the rate of CO formation when the combustion air to the gas-fired appliance becomes vitiated. Such elevated levels of CO₂ can sometimes be accompanied by very low levels of CO, for example when the gas-fired appliance concerned is direct fired. When sampling ambient air for leakage of CO₂, both CO and CO₂ concentrations should be monitored.

COMMENTARY ON 7.1

Spillage of combustion products, particularly in confined spaces, can lead to contamination of the combustion air stream to a gas-fired appliance. When sufficiently contaminated by CO₂ (typically 1.5% to 2% by volume), the concentration of CO in the combustion products rapidly rises. Therefore, elevated levels of CO₂ in excess of 1.5% by volume can be indicative of subsequent rapid CO production.

Busy roads and car park exits can cause a significant rise in the background levels of CO and CO₂ outdoors.

Prior to carrying out ambient air testing, it is advisable to refer to the additional investigation considerations given in Annex A. For investigations including domestic gas-fired appliances installed in non-domestic premises, also refer to Clause 10. For investigations involving different gas-fired appliance chimney types and system types, also refer to Clause 9.