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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

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Contents

Summary of pages
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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 (CO_2) 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/CO_2 ratios or CO/CO_2 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 (CO_2) 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 (NOx), predominantly nitrogen monoxide (nitric oxide, NO) and nitrogen dioxide (NO_2). 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 CO_2 in ambient air within premises is typically different from the concentration of CO_2 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/CO_2) although some equipment manufacturers might use specific flue gas concentrations of CO_2 and O_2 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 CO_2 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 CO_2

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:

a) to protect life;

b) to protect property;

c) to locate fuel-burning appliances;

d) to locate any escape of gas, fumes, smells or spillage/leakage of combustion products;

e) to confirm the safe installation and operation of gas-fired appliances;

f) to advise the responsible person of required remedial action; and

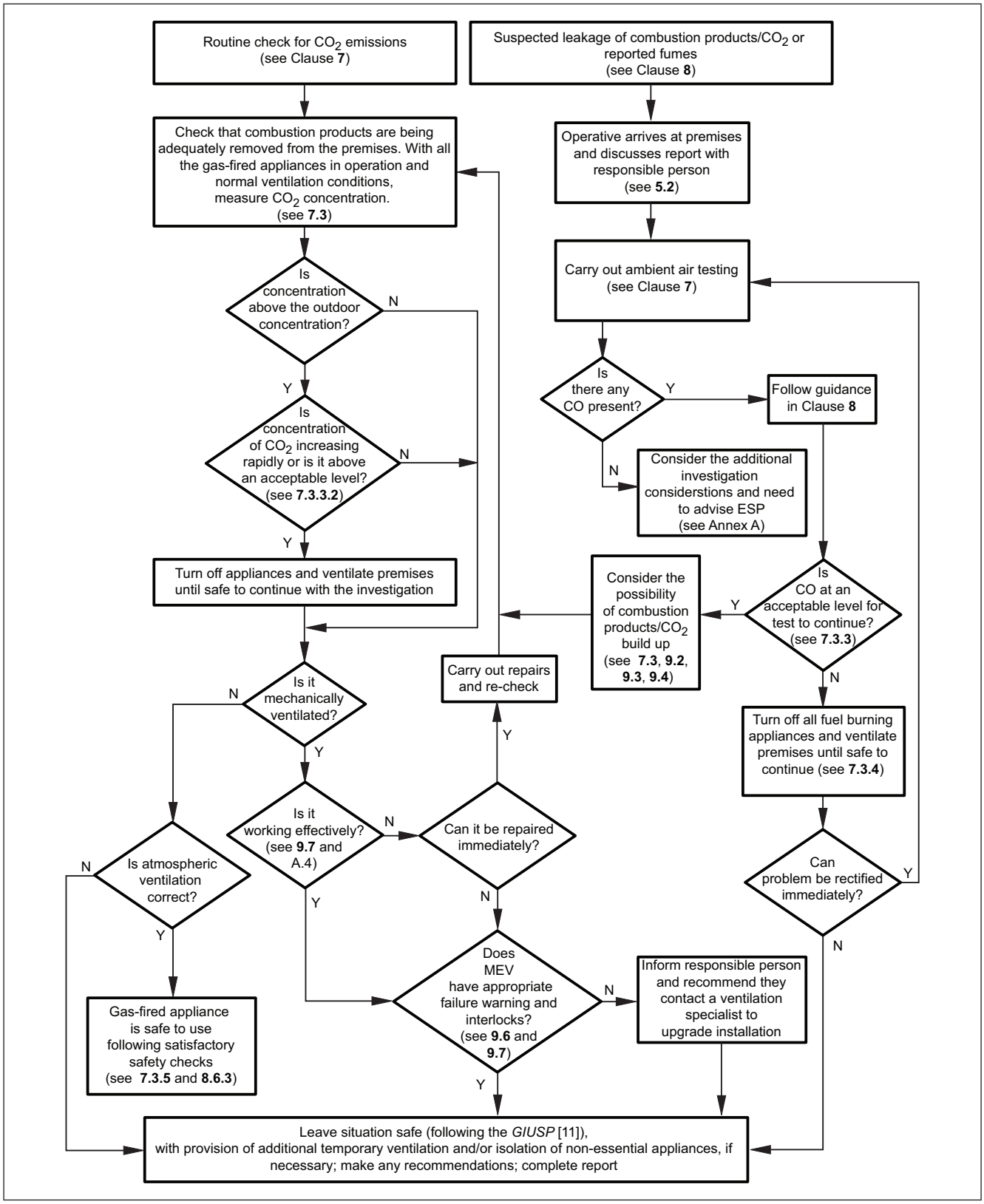
g) to complete the necessary reports, documentation and actions in accordance with the Gas Industry Unsafe Situations Procedure (GIUSP) [11].

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 CO_2 emissions and investigations regarding suspected leakage of combustion products from gas-fired appliances.

Figure 1 **Procedure for routine checks for CO_2 emissions and the suspected leakage of combustion products/CO_2 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 CO_2 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

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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 (O_2) and CO concentration in a sample of combustion products drawn from the chimney/flue system; and

g) they measure or calculate the CO_2 concentration and CO/CO_2 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 CO_2 in indoor ambient air.

NOTE Electronic portable combustion analysers conforming to BS 8494 that read CO_2 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 CO_2 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 O_2.

NOTE 1 Electronic portable combustion gas analysers of the type that directly measure CO and O_2 calculate a CO_2 concentration from the O_2 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 ±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 CO_2 in ambient air

To detect the presence of CO_2 in non-domestic premises, electronic portable combustion analysers that directly measure CO_2 in ambient air should conform to BS 8494.

Electronic portable combustion gas analysers can indicate gas concentrations of CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 in ambient air

7.1 General

Normally, the increase in CO and CO_2 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 CO_2. However, excessive levels of CO_2 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 CO_2 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 CO_2, both CO and CO_2 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 CO_2 (typically 1.5% to 2% by volume), the concentration of CO in the combustion products rapidly rises. Therefore, elevated levels of CO_2 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 CO_2 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**.*

7.2 Preparing an electronic portable combustion gas analyser for ambient air testing

7.2.1 The electronic portable combustion gas analyser should be selected in accordance with Clause **6**.

7.2.2 The electronic portable combustion gas analyser should be switched on and set to zero in accordance with the manufacturer's instructions. This should be carried out in outdoor air, at a location as near as practicable to the ambient air to be tested. It is advisable to check that the O_2 reading in outdoor air is 20.9% which is the concentration of O_2 in clean air. When the CO_2 level is being determined, the relevant fuel gas should be selected on the analyser.

7.2.3 Generally, electronic portable combustion gas analysers do not measure absolute levels of CO and CO_2 within an occupied space. They measure the increase in CO and CO_2 levels (which could, for example, emanate from a faulty gas-fired appliance) above the outdoor background levels of CO and CO_2.

7.2.4 Where the electronic portable combustion gas analyser does measure absolute CO and CO_2 levels, the levels of CO and CO_2 in outdoor air should be measured before that within the premises. The outdoor air gas levels should then be subtracted from the levels recorded in the premises.

7.2.5 Electronic portable combustion gas analysers that always measure from a position of absolute zero do not need to be set to zero in the outdoor air. In this instance the manufacturer's instructions should be consulted and followed.

7.2.6 Once set to zero, the electronic portable combustion gas analyser should not be switched off during the ambient air test. Where it is switched off, the analyser needs to be re-set to zero before taking further readings.

7.2.7 Where the electronic portable combustion gas analyser cannot be set to zero, the manufacturer's instructions should be consulted. It might indicate that the analyser is faulty or that its sensors require recalibration and/or replacement.

7.3 Ambient air testing for CO and CO_2

7.3.1 Where to measure CO_2 concentration levels

7.3.1.1 CO_2 in the ambient air can be tested using the general procedure specified in **7.3.2** or during sampling conducted by the operative when assessing the safety of the environment.

7.3.1.2 CO_2 should be measured in the following locations:

a) in the outdoor air;

b) around gas-fired appliances at a height of approximately 2 m (particularly where people are likely to be exposed to gas emissions);

NOTE A height of 2 m is generally considered to be representative of the average head height of a standing person.

c) at the centre of the room at a height of approximately 2 m;

d) inside the canopy of any installed MEV system; and

e) at chimney joints and air re-entry locations.

7.3.2 General procedure for ambient air testing of CO or CO_2

*NOTE See Figure 1 for a flow diagram showing the testing procedures for an operative when called out for a routine check for the concentration of CO_2 in combustion products or when called out to investigate a suspected leakage of combustion products or CO_2. Refer to Clause **10** for additional recommendations for ambient air testing, including domestic gas-fired appliances installed in non-domestic premises. Refer to Clause **9** for additional recommendations for investigations involving different gas-fired appliance chimney types and system types.*

7.3.2.1 Persons not required to carry out the ambient air test should be evacuated from the area being tested.

7.3.2.2 Where practicable, and with the agreement of the responsible person, fossil-fuel-burning equipment should be switched off or extinguished as it can affect the results of the ambient air tests. The area should be ventilated until the indoor and outdoor levels of either CO or CO_2 (whichever gas is being tested) are the same.

NOTE 1 There can be more than one appliance that is a source of CO or CO_2 on the premises that can affect the results of ambient air tests. It should be remembered that both CO and CO_2 can come from sources other than gas-fired appliances, such as solid fuel appliances, and that CO_2, in particular, is produced through respiration by plant and animal sources.

NOTE 2 Where other fuel burning appliances are present and in operation, where practicable, check them for production of CO and spillage. Where these appliances are thought to be the cause of the problem, seek expert advice. [1)]

7.3.2.3 External doors, windows and customer-adjustable ventilation should be closed before ambient air testing begins.

*NOTE See **A.3.2.3** for more information regarding the migration of CO in a building.*

7.3.2.4 An initial visual inspection of combustion equipment should be carried out to identify obvious defects. At the same time a sample reading should be taken of the ambient air.

7.3.2.5 Suspect gas-fired appliances should be individually operated and an atmospheric build-up test carried out in accordance with BS 7967-2:2005, **5.3**.

7.3.2.6 Gas-fired appliances and MEV equipment within the area to be tested should be fully operational. Additional checks should be made in accordance with **9.7** for MEV equipment. The entire testing process should be carried out over a time period agreed between the operative and the responsible person.

7.3.2.7 An open-ended sampling probe should be positioned approximately 2 m above floor level in the centre of the area to be tested and at least 1 m away from installed suspect gas-fired appliances. Tests might need to be carried out in a number of locations, as outlined in **7.3.1**.

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1) At the time of publication such advice is known to be available from specialist organizations such as the Gas Safe Register, www.gassaferegister.co.uk, the Oil Firing Technical Association, www.oftec.co.uk, Tel. 0845 6585080, and the Solid Fuel Association, www.solidfuel.co.uk, Tel. 0845 6014406, as appropriate.

7.3.2.8 The level of CO or CO_2 (whichever is being tested) should be recorded for a minimum of 15 min. Where the indoor level of either gas starts to rise during this period, the migration of gas from other sources should be investigated.

*NOTE See **A.3.2.3** for more information regarding the migration of CO in a building.*

7.3.2.9 CO or CO_2 level measurements should be clearly recorded and the results made available to the responsible person in accordance with **11.2**. The measurement should be repeated either for each gas-fired appliance in turn or for a combination of gas-fired appliances until the source of CO or CO_2 has been identified or the original problem resolved.

*NOTE Air movement within spaces could prevent the correct operation of combustion and chimney systems or draw CO or CO_2 from other spaces. Consequently, for each test it is necessary to take account of the effect of mechanical air movement and extraction equipment such as cooker hoods/canopies, extractor fans, mechanical ventilation, radon ventilation systems, tumble dryers, warm air circulation fans and gas-fired appliance flue interaction between spaces. See **9.6**, **9.7**, **A.3**, **A.4** and **A.5** for more information.*

7.3.2.10 CO or CO_2 readings should be judged to be acceptable or unacceptable in accordance with **7.3.3** and acted on accordingly.

7.3.3 Excessive levels of CO and CO_2 in ambient air

7.3.3.1 Excessive CO levels

Where levels of CO exceed an 8 h time-weighted average of 10 ppm, action should be taken in accordance with **7.3.4**. However, when carrying out the test for commercial ranges or cookers in accordance with **10.8**, higher intermittent levels may be acceptable under certain risk-assessed conditions. In such circumstances, operatives should not assess exposure by time-weighted averages of concentrations of CO greater than 10 ppm.

*COMMENTARY ON **7.3.3.1***
Only competent people with training and experience in the toxicological effects of CO are able to advise on exposure times for concentrations in excess of 10 ppm.

It can be acceptable to continue testing above a CO level of 10 ppm where a risk assessment has been carried out in accordance with COSHH [12]. Further guidance on COSHH is given in the Health and Safety Commission (HSC) Approved Code of Practice and Guidance, Control of substances hazardous to health – The Control of Substances Hazardous to Health Regulations 2002 *[13].*

The CO levels given in this British Standard refer to substantially higher levels than outdoor background conditions. Outdoor background levels of CO rarely exceed 2 ppm. However, the levels can be significantly higher if, for example, the premises are near a busy road, in a garage or on an industrial estate.

The aim of this British Standard is to detect sources of CO so that faults can be rectified. Readings of CO obtained using this British Standard do not necessarily determine whether CO levels are a hazard to health.

The World Health Organization (WHO) Environmental Health Criteria 213 for Carbon Monoxide *[14] recommends an 8 h time-weighted average of 10 ppm for CO concentrations in outdoor air. These guidelines have been recommended for CO concentrations in indoor air by the Department of Health's Committee on the Medical Effects of Air Pollutants. This means that the general population can be exposed to a concentration of 10 ppm for 8 h without any known health risk.*

For a list of the effects of CO on human beings, see ***B.1****.*

7.3.3.2 Excessive CO_2 levels

Where levels of CO_2 exceed an 8 h time-weighted average of 2800 ppm, action should be taken in accordance with **7.3.4**. However, when carrying out the test for commercial ranges or cookers in accordance with **10.8**, higher intermittent levels of CO_2 may be acceptable under certain risk-assessed conditions.

COMMENTARY ON ***7.3.3.2***
It can be acceptable to continue testing above a CO_2 level of 2800 ppm where a risk assessment has been carried out in accordance with COSHH [12]. Further guidance on COSHH is given in the Health and Safety Commission (HSC) Approved Code of Practice and Guidance, Control of substances hazardous to health – The Control of Substances Hazardous to Health Regulations 2002 *[13].*

The CO_2 levels given in this British Standard are substantially higher levels than outdoor background conditions. Outdoor background levels of CO_2 rarely exceed 400 ppm, although levels can be significantly higher if, for example, the premises are near a busy road, in a garage or on an industrial estate.

For workplace exposure limits and health effects for CO_2, see Table B.2.

7.3.4 Action for excessive levels of CO or CO_2 in ambient air

7.3.4.1 Where levels in the ambient air exceed 10 ppm for CO (see **7.3.3.1**) or 2800 ppm for CO_2 (see **7.3.3.2**), the following steps should be taken.

- A risk assessment should be carried out (see **5.4**).
- Gas and fuel burning appliances should be turned off, wherever practicable, and non-essential appliances isolated.
- Occupants should be evacuated from the affected space.
- Windows, shutters and doors should be opened to the outside air, wherever practicable, to ventilate the occupied space.

The order of the steps should be dependent on the circumstances as judged by the operative.

NOTE 1 A risk assessment can be used to determine whether a suspect gas-fired appliance is safe to turn off. Attention is drawn to the Health and Safety at Work Act (HSWA) [15].

The investigation should not continue until the CO_2 level has been measured and confirmed to be below 2800 ppm.

NOTE 2 Attention is drawn to the HSE guide, EH40: Workplace exposure limits: Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended), *2005 [16], for occupational exposure limit(s) for CO_2. These are 0.5% (5000 ppm) for an 8 h time-weighted average and there is a short-term exposure limit of 1.5% (15000 ppm) for a 15 min time-weighted average.*

7.3.4.2 Where the risk assessment results indicate that a suspect gas-fired appliance cannot be turned off, the operative should inform the responsible person to make the site safe and evacuate the occupants as a priority.

7.3.4.3 The source of CO and/or CO_2 should be determined in accordance with **8.1**. Where the source is a gas-fired appliance (i.e. the source is combustion), it should be classified in accordance with the GIUSP [11]. Wherever practicable, remedial work should be carried out. When remedial work cannot be carried out, the guidance given in the current GIUSP [11] should be followed.

NOTE 1 Attention is drawn to Regulation 34, "The Use of Appliances" of the GSIUR [5]. Guidance on Regulation 34 is given in the HSC Approved Code of Practice and Guidance, Safety in the installation and use of gas systems and appliances *(HS(L)56) [6].*

NOTE 2 Attention is drawn to the GIUSP [11] in relation to the CO levels measured when responding to ambient levels of CO and CO_2.

7.3.5 Final checks to premises under test

7.3.5.1 Gas safety checks should be completed.

NOTE Attention is drawn to the GSIUR [5], Regulation 26.

7.3.5.2 The responsible person should be notified of any defects or problems. Where it is not practicable to do this, the supplier of gas to the equipment or the gas transporter should be notified. This might be necessary where equipment is supplied with liquefied petroleum gas.

NOTE Attention is drawn to the current GIUSP [11].

7.3.6 Re-entry to area under test

7.3.6.1 The ambient air should be checked continually, working inwards from the point of access to the area under test towards the suspect gas-fired appliance(s). The premises should not be re-entered for further investigations until CO levels are below 10 ppm and CO_2 levels are below 2800 ppm.

7.3.6.2 The premises should not be re-occupied for use until the gas-fired appliance(s) are put back into safe operation or else made safe. Unless specific circumstances dictate otherwise (see Commentary on **7.3.3.1**), electronic portable combustion gas analyser readings should be checked to be at a stable level below 10 ppm for CO and 2800 ppm for CO_2.

NOTE An example of making a gas-fired appliance safe would be to disconnect it from the gas supply.

7.3.6.3 Where there are specific circumstances that require re-entry at levels of CO and CO_2 other than below 10 ppm for CO and 2800 ppm for CO_2, these should be written into a risk assessment (see **5.4**) and adhered to by the operative. The risk assessment should take into account safe lengths of exposure to CO and/or CO_2 (see the WHO carbon monoxide exposure guidelines [14] for further information and Annex B for the effects of CO and CO_2 on human beings).

8 Investigating CO and CO_2 in the combustion products stream of suspect gas-fired appliances

*COMMENTARY ON CLAUSE **8***
*Prior to carrying out combustion products 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**.*

8.1 Identifying suspect gas-fired appliances

Suspect gas-fired appliances should be identified through the combined results of the following.

- Visual examination of gas-fired appliances for signs of spillage, combustion problems, incorrect flueing and ventilation, and overall condition.
- Visual examination of other fuel-burning appliances for signs of spillage and/or combustion problems, where also present.
- Information gained from the responsible person (see **5.2**).

Where a fuel-burning appliance other than a gas-fired appliance is identified as suspect, the responsible person should be advised to seek expert assistance.

8.2 Initial examination of a suspect gas-fired appliance

8.2.1 After identifying a suspect gas-fired appliance in accordance with **8.1**, checks should be made to ensure that:

a) the ventilation requirements are correct;

b) the chimneys are in good working condition along their entire length, where applicable;

c) the chimneys terminate correctly, where applicable;

d) the operating pressures of burners are set in accordance with manufacturer's instructions (see Commentary on **8.2.1**);

e) the gas rate is correct (see Commentary on **8.2.1**);

f) adjacent equipment or ventilation that could affect combustion performance is in operation (see Commentary on **8.2.1**); and that

g) the equipment seals and gaskets on the gas-fired appliance are functioning correctly.

*COMMENTARY ON **8.2.1***
Adjacent equipment or ventilation includes fans, doors and windows.

It is permissible to use the measured combustion performance to demonstrate that the suspect gas-fired appliance is operating safely, where:

i) there is no meter to directly measure the heat input into the gas appliance; and

ii) it is not practicable to measure the operating pressure of the gas appliance because it incorporates a pre-mix burner and a zero set pressure regulator.

See the Gas Safe Register Technical Bulletin 021 [24], which gives guidance on the HSE Certificate of Exemption No.1 2008.

Where the measured combustion performance is used to demonstrate that the suspect gas-fired appliance is operating safely, the operative will need to:

*1) have access to the boiler manufacturer's instructions and a calibrated electronic portable combustion gas analyser (see Clause **6**); and*

*2) use and maintain the electronic portable gas analyser in accordance with **6.4**.*

8.2.2 Where a combustion test can be carried out on the suspect gas-fired appliance using an electronic portable combustion gas analyser, this should be carried out in accordance with **8.4** and **8.5**.

8.2.3 Where it is not practicable to carry out a combustion test on a suspect gas-fired appliance using the procedure given in **8.5**, a detailed examination of the suspect gas-fired appliance should be carried out in accordance with **8.3**.

8.3 Detailed examination

8.3.1 A detailed examination should be carried out whenever:

- it has not been practicable to check the CO/CO_2 ratio or CO/CO_2 readings of a suspect gas-fired appliance in accordance with the appropriate methods; or
- the CO/CO_2 ratio or CO/CO_2 readings are greater than those stated in Table 3 for domestic gas-fired appliances operating in non-domestic premises; or
- the CO/CO_2 ratio or CO/CO_2 readings are greater than those stated in the manufacturer's instructions.

The detailed examination should begin with the following checks and actions.

a) Check that gas and electrical supplies are isolated.

b) Check that components that could affect combustion are undamaged and replace as necessary.

*NOTE A high CO/CO_2 ratio or CO/CO_2 reading might be due to damage or the ageing of components of the gas-fired appliance. If this is the case then the relevant components need to be replaced and the combustion test repeated. Where a component is replaced, it is necessary to burn off anything on the new component that is the result of its manufacture in order to obtain readings that would result from a used component (see **8.3.4**).*

c) Inspect and, where necessary, clean the injectors, venturies, burners, lint guards, air path to the combustion chamber and any other items recommended by the appliance manufacturer's instructions.

d) Inspect and clean any pilot/injector present.

e) Inspect and, where necessary, clean the heat exchanger, fluehood and flueways, checking that any baffles, etc. are correctly positioned.

f) Check that any seals and fastenings are present, in good condition and secured in accordance with the manufacturer's instructions.

g) Reinstate gas and electricity supplies.

h) Check flame picture, following the advice given in the gas-fired appliance manufacturer's instructions, where appropriate.

i) Decide if it is practicable to carry out a combustion performance test (see **8.3.3**).

8.3.2 Where it is not practicable to carry out a combustion performance test, perform the final checks listed in **8.6.3**.

8.3.3 Where it is practicable to carry out a combustion performance test, carry one out in accordance with **8.4** and **8.5.** Where the test results are within manufacturer's guidelines and do not exceed the CO/CO_2 ratio readings given in Table 3 for domestic gas-fired appliances operating in non-domestic premises, perform the final checks in accordance with **8.6.3**. Where the CO/CO_2 ratio or CO/CO_2 readings are above the limits given in Table 3 for domestic gas-fired appliances operating in non-domestic premises or above the acceptable levels given in the manufacturer's instructions, then **8.3.1** a) to **8.3.1** i) should be repeated. Where the combustion ratio or readings remain unacceptably high, help should be sought from the appropriate technical support service, such as the gas-fired appliance manufacturer.

8.3.4 Where a new component has been fitted, operate the appliance at full rate and take a combustion reading after 10 min. Where the reading is unacceptable (see Table 3 for acceptable levels for domestic gas-fired appliances operating in non-domestic premises or the acceptable levels given in the manufacturer's instructions) or still rising, continue sampling at 20 min intervals until a stable, acceptable level is reached or the level stabilizes at an unacceptable level. When the latter occurs, if the level does not fall within 20 min, inspect the gas-fired appliance further to establish the cause of the high reading.

NOTE For condensing boilers, it might be necessary to run the gas-fired appliance at high and low fire and take combustion readings at both settings.

8.4 Preparation and selection of an electronic portable combustion gas analyser for use for testing gas-fired appliance combustion performance

To detect CO and CO_2 in the combustion products stream from gas-fired appliances, the selected electronic portable combustion analyser should conform to BS EN 50379-3 (or BS 7927:1998 including Amendment 1, see **6.1.1**). It should be prepared in accordance with **7.2**.

8.5 Combustion performance test procedure

8.5.1 The suspect gas-fired appliance should be operating at its designed maximum heat input rating throughout the test period.

8.5.2 Ambient air testing should be carried out in accordance with **7.3**.

8.5.3 The suspect gas-fired appliance should be tested using an electronic combustion gas analyser in line with the recommendations given in **8.3.3** and **8.3.4** to check for CO and CO_2 increases. The procedures for testing gas-fired appliances should be modified in accordance with the recommendations for their specific chimney types, as given in Clause **9**, or Clause **10** for additional recommendations for domestic gas-fired appliances in non-domestic premises.

*NOTE Clause **9** gives specific guidance for flueless gas-fired appliances, open-flued gas-fired appliances, room-sealed gas-fired appliances, fan dilution systems and MEV systems. Clause **10** gives specific guidance for flueless, open-flued and room-sealed domestic gas-fired appliances, warm air heaters, fires, fire/back boilers and fire/back circulators, and cookers.*

8.5.4 A spillage test should be carried out in accordance with BS 5440-1:2008, **6.3.2.3**, where appropriate, or the manufacturer's instructions for gas appliances above a net heat input of 70kW. Where spillage is confirmed, unless the investigation requires determination of the maximum CO_2 and/or CO levels, or other suspect gas-fired equipment has been identified (see **8.1**), it is not necessary to continue testing. The confirmed leaking gas-fired appliance should then be investigated further to identify the problem, which should be rectified where practicable. However, where a suspect gas-fired appliance is found to be leaking CO_2 and/or CO, it should only be operated for short periods to avoid prolonged exposure of the operative to combustion products (see **7.3.3**).

8.5.5 The burner operating pressure and/or gas rate should be checked in accordance with the manufacturer's instructions, where practicable, and a visible flame compared with a flame picture, where provided by the manufacturer.

*NOTE Refer to Commentary on **8.2.1**.*

8.5.6 Where the manufacturer's combustion performance criterion is more detailed than recommended, or where it is not practicable to check the combustion performance of a gas-fired appliance, a detailed examination should be carried out, in accordance with **8.3**.

*COMMENTARY ON **8.5.6***
Manufacturers of non-domestic gas-fired appliances tend not to specify a combustion performance ratio value at which operation is considered to be satisfactory. Values for CO and/or CO_2 (and possibly O_2) concentrations sampled in the combustion products are generally specified for both commissioning and maintenance purposes. Therefore, where the manufacturer's instructions do not provide specific guidance for checking combustion, combustion performance ratio values cannot be used to assess combustion. This is unlike domestic gas-fired appliances.

It is essential to consult the manufacturer's instructions as they might specify particular requirements for individual appliances. Some appliance manufacturers specify particular combustion requirements (CO_2, O_2, CO or CO/CO_2 combustion ratio).

8.5.7 Where no spillage is detected and the combustion performance ratio is within the recommended limits given in Table 3 or the acceptable levels given in the manufacturer's instructions, as applicable, checks should be carried out in accordance with **8.6.3** and **8.6.4**.

8.5.8 Where no fault can be identified, other potential sources of CO/CO_2 or smells should be considered, as described in **8.6.5**.

8.5.9 Where more than one suspect gas-fired appliance is identified, these should be investigated in turn, in accordance with **8.2**.

8.6 Combustion performance outcomes

8.6.1 General

Levels of CO and/or CO_2 that exceed the acceptable levels given in Table 3, or that exceed the levels specified by the manufacturer, as applicable, should be dealt with in accordance with **8.6.2**. Where acceptable levels of CO and/or CO_2 are registered, then final checks on the suspect appliance should be carried out in accordance with **8.6.3** and **8.6.4**, as appropriate.

Table 3 **Acceptable combustion performance ratio levels for domestic gas-fired appliances operating in non-domestic premises**

Appliance type		CO/CO_2 ratio
Back boiler unit	Boiler unit	0.008
	In combination with fire	0.020
Central heating boiler		0.008
Circulator		0.010
Combination boiler		0.008
Condensing boiler	Regular boiler	0.004
	Combi-boiler	
Flued space heater	Fire	0.020 [A)]
	Convector heater	
Flueless space heater	Fire	0.001
	Convector heater	
Flueless cabinet heater (LPG)		0.004
Water heater – flued and flueless		0.020
Warm air heater		0.008
Flueless cookers	Cooker oven	0.008
	Cooker hob	Assess flame picture
	Cooker grill (CE marked)	0.010
	Cooker grill (non CE marked)	0.020
Range oven (flued)		0.020
Refrigerator (LPG)		0.007
Tumble dryer	Flued	0.010
	Flueless	0.001
Gas lights (LPG)		0.020

[A)] This may differ to be in accordance with the manufacturer's instructions where a lower value is specified.

8.6.2 Unacceptable CO/CO_2 ratios or excessive CO and/or CO_2 readings

CO/CO_2 ratios might be above the acceptable level given in Table 3 or CO and/or CO_2 readings might exceed the manufacturer's specification, as applicable. This could be the result of the gas-fired appliance and/or its component part(s) being subject to one or more of the following:

a) misuse;

b) lack of maintenance;

NOTE 1 This can sometimes be through use, e.g. excessively soiled range grill frets or misplaced baffles in combustion chambers.

c) damage;

d) ageing.

NOTE 2 Some manufacturers advise that their equipment is set up using a specified oxygen level in the flue gases.

The gas-fired appliance should be examined for evidence of such wear and a detailed examination carried out in accordance with **8.3**. Damaged parts should be replaced with new parts that are approved by the gas-fired appliance manufacturer. Excessively soiled parts should either be cleaned or replaced.

The gas-fired appliance should be re-tested in accordance with **8.5** to confirm that the problem has been rectified.

NOTE Attention is drawn to the requirements of the GSIUR [5], Regulation 34 and the GIUSP [11]. Guidance on Regulation 34 is contained in HSC Approved Code of Practice and Guidance (HS(L)56) [6].

8.6.3 Final checks to suspect gas-fired appliances

Where acceptable readings of CO and/or CO_2 are measured, then the following final checks and tests should be performed.

a) Carry out a leak test for any disturbed gas connections. Test for gas tightness where a gas escape has been previously identified or repaired.

b) Check that the burner operating pressure and/or gas rate is correct.

*NOTE See Commentary on **8.2.1**.*

c) Where practicable, carry out a final combustion performance test to check that the combustion performance is within the limits given in Table 3 or the manufacturer's instructions, as applicable.

d) Check the operation of any flame supervision device using the manufacturer's approved method.

e) Check that all seals or fastenings are present, in good condition and secured in accordance with the manufacturer's instructions. Be especially vigilant with room-sealed positive fan pressure gas-fired appliances.

NOTE See Gas Safe Register's Technical Bulletin 006, Industry guidance for the checking of case seals and general integrity of room-sealed fan assisted positive pressure gas appliances *[17].*

f) Where appropriate for the gas-fired appliance design, carry out a spillage test.

g) Check that any warning labels necessary for safe use of the gas-fired appliance are present and correct.

Where the results from the checks are satisfactory, then the gas-fired appliance should be confirmed as no longer suspect.

8.6.4 Additional checks when combustion performance is satisfactory

8.6.4.1 Where the detailed examination in **8.3** has not been necessary, the following checks should be carried out.

a) Visually examine appropriate areas of the gas-fired appliance for signs of spillage, heat stress, corrosion or damage. It might be necessary to remove the outer casing to do this.

b) Visually examine all heat exchangers for obstruction or surface deposits, cleaning as necessary.

8.6.4.2 Replace any parts necessary to restore operation.

8.6.5 Generation of CO, smells and fumes when no gas-fired appliance faults have been identified

Where no faults have been found with the gas installation, the following possibilities should be considered.

a) The generation of CO from:
   1) smoking;
   2) other fuel-burning equipment;
   3) vehicles or generators in attached buildings/dwellings;
   4) engines on boats;
   5) adjacent properties.

b) The emission of smells and fumes as the result of:
   1) gas escapes on equipment;
   2) poorly cured fibreglass log effects;
   3) paint smells, particularly on new equipment;
   4) dust on appliance surfaces;
   5) recent cavity wall insulation;
   6) recent painting and decorating activity;
   7) use of solvents and adhesives;
   8) damp proofing or timber treatment;
   9) external sources, such as barbecues or bonfires, situated outside the premises;
   10) drains;
   11) gas migrating from adjacent properties.

*NOTE See **A.3.2.3** for more information regarding the migration of CO in a building.*

9 Gas-fired appliance chimney types and system types

9.1 General

Operatives attending non-domestic premises might be required to examine a standard gas-fired appliance that can be domestic, commercial, or customized process plant/equipment. These should be tested in accordance with BS 7967-1, BS 7967-2, BS 7967-3 or BS 7967-4, as appropriate.

*NOTE For further information regarding testing domestic gas-fired appliances installed on non-domestic premises, see Clause **10**.*

Some types of process plant gas-fired appliances are specifically designed to operate at a higher level of CO_2 and CO than standard gas-fired appliances. The responsible person or site engineer should always be consulted in these instances.

Specific guidance and recommendations for the testing of ambient air and combustion products stream of gas-fired appliances with different chimney types are given in **9.2** to **9.5**. Guidance and recommendations

for the testing of gas-fired appliances with fan dilution systems are given in **9.6** and MEV systems in **9.7**.

The following types of gas-fired appliance could be encountered by an operative and are classified in accordance with BS 5440-1 and PD CEN/TR 1749.

- Flueless (Type A) (see **9.2**)
- Open-flued gas-fired appliance with draught diverter (Type B1) (see **9.3**)
- Open-flued gas-fired appliance without a draught diverter (Type B2) (see **9.3** and **9.4**)

  NOTE This was previously called a closed flue.
- Room-sealed gas-fired appliance (Type C) (see **9.5**).

9.2 Flueless (Type A)

Flueless gas-fired appliances release some CO and CO_2 into the premises, even if there is an installed extraction system. This type of equipment should therefore be tested using an atmospheric build-up test procedure in accordance with BS 7967-2:2005, **5.3**.

When testing ambient air, probes should be sited wherever employees are expected to work (see BS 6173, BS 6896 and BS 6230 for further guidance).

*COMMENTARY ON **9.2***
Examples of flueless gas-fired appliances are as follows.

a) Open top/solid top ranges and gas fryers in catering establishments.

b) Some tumble dryers and rotary irons in laundrettes.

c) Greenhouse heaters, grain driers and egg hatchers on farms.

d) Process plant/equipment, overhead radiant tube, radiant plaque heaters and direct-fired warm air heaters in factories or warehouses.

e) Swimming pool boilers and patio heaters in leisure centres.

See the HSE Catering Sheet No. 23 (Revision 1) [18] for more information when assessing ambient air in catering premises where a canopy or where an MEV is being used with a flueless gas-fired appliance.

9.3 Open flue (Type B)

9.3.1 Testing the combustion performance of open-flued gas-fired appliances

The combustion performance of Type B open-flued gas-fired appliances should be tested using electronic portable combustion gas analysers and sampling, in accordance with **8.4** and **8.5**. Visual inspection and standard flue-flow tests should also be used to test combustion performance.

Where an open-flued gas-fired appliance does not have a sampling point, it might be necessary to drill a probe hole into the chimney. Where the gas-fired appliance has an atmospheric type burner and a draught diverter, the probe hole should be located in the secondary flue, at a distance above the draught diverter equal to a length two times the flue diameter. The only exception to this is where alternative instructions have been specified by the manufacturer.

Where the gas-fired appliance has a forced draught type burner, the sampling hole should be situated in the horizontal flue section after the boiler flue connector to result in accurate readings. The sampling hole should be placed at a distance of approximately 1 m from the connector.

Atmospheric build-up measurements taken through sampling should be in accordance with BS 7967-2:2005, **5.3**. During such a build-up test, a continuous rapidly rising CO_2 reading above 0.28% (2800 ppm) indicates combustion product spillage. If levels were to rise above 1.5% (15000 ppm), vitiation of the combustion air supply could lead to rapid CO production within an appliance compartment (see **9.3.2**).

*COMMENTARY ON **9.3.1***
Open-flued gas-fired appliances can consist of natural draught, fanned draught, single chimneys or multiple chimneys connected to a common header and terminating outside of the premises. Attention is drawn to the Clean Air Act 1993 [19].

Open-flue chimney performance can be affected by poor routing design, incorrect termination positions, severe weather conditions, alterations to adjacent building structures or deterioration and blockages. These can cause leakage of combustion products inside the premises, usually via the flue break/draught diverter.

The pressure differences that create flow within a chimney are very small. Care should be taken when positioning the probe of an electronic combustion gas analyser so that it does not induce combustion spillage from the chimney.

9.3.2 Ambient air test for open-flued gas-fired appliances in compartments

Where the open-flued gas-fired appliance is installed in a compartment, checking for spillage with the compartment door closed in accordance with BS 7967-2:2005, **6.3.1**, should be considered to replicate the conditions of its normal mode of operation.

Door closure might mean that the spillage test given in BS 5440-1:2008, **6.3.2.3**, using smoke devices is impractical. Consideration should therefore be given to measuring combustion product build-up using an electronic portable combustion gas analyser to measure CO_2 in ambient air (see **6.3**) with the compartment door closed and taking remote samples as the gas-fired appliance operates.

When ambient air testing is carried out, the gas-fired appliance should be operated at full rate until the CO and/or CO_2 readings stabilize or begin to fall, whichever occurs first.

NOTE Due to its confined nature and smaller volume of air, the normal operating conditions within a compartment with a gas-fired appliance in use can produce higher stable ambient readings of CO and CO_2 than those expected with the same gas-fired appliance operating in a room or open space. Rapidly rising CO_2 levels within a compartment can give an earlier indication of spillage than CO, as CO might not begin to be produced until a significant level of CO_2 (approximately 1.5% to 2% by volume) builds up to vitiate the combustion air supply.

9.4 Open-flued without a draught diverter (Type B2)

Testing for build-up of CO and/or CO_2 from combustion products leaking into the room where the gas-fired appliance is positioned should be carried out in accordance with Clause **7**. The gas-fired

appliance should be operated at full rate until the CO and/or CO_2 readings stabilize or begin to fall, whichever occurs first.

NOTE With no down-draught diverter available in this type of chimney leakage of combustion products is likely at points of mechanical breakdown of the flue assembly, draught stabilizers, or around air intakes to the combustion chamber of the gas-fired appliance.

9.5 Room-sealed gas-fired appliance (Type C)

9.5.1 Testing the combustion products stream of room-sealed gas-fired appliances

To obtain a well-mixed representative sample from a room-sealed gas-fired appliance, the probe tip should be positioned 200 mm inside the combustion products outlet duct.

Where the flow of combustion products in the chimney cannot be accessed due to the placement of the gas-fired appliance, a detailed examination should be carried out in accordance with **8.3**. This might be necessary, for example, if the room-sealed gas-fired appliance is installed at a high level without a purpose-designed sampling point.

NOTE Care needs to be taken when sampling in the outlet of a fanned flue gas-fired appliance to minimize the possibility of the probe damaging the fan.

9.5.2 Ambient air tests for room-sealed gas-fired appliances

Ambient air testing should be carried out in accordance with Clause **7**. The gas-fired appliance should be operated at full rate until the CO and/or CO_2 readings stabilize or begin to fall, whichever occurs first.

NOTE This type of gas-fired appliance can operate with a pressure within the appliance casing that is either higher or lower than the ambient air pressure.

9.6 Fan dilution systems

9.6.1 General

Prior to testing, the gas-fired appliance should be checked to have a failure warning and be interlocked with the dilution fan to prevent the equipment from firing in the event of reduced flow or fan failure.

When testing levels of CO and CO_2 in the combustion products stream, the sample probe should be positioned 200 mm inside the dilution outlet duct.

*COMMENTARY ON **9.6.1***
Fan diluted chimney systems are generally designed so that the combustion products are diluted to give levels no greater than 10 000 ppm (1.0%) CO_2 and 50 ppm CO at the discharge point to outside air. These levels are measured above ambient air readings.

Guidance on the design and installation of fan dilution systems can be found in IGE/UP/10, Edition 3, Installation of flued gas appliances in industrial and commercial premises *[20].*

The specific design extract and ventilation rates for radiant heating systems are given in BS EN 13410 and BS 6896, and guidance for direct-fired air heating is given in BS 6230.

Typically for natural gas in the UK, the maximum CO_2 concentration is approximately equivalent to one volume of combustion products to 38 volumes of outside air being supplied to the spaces being heated. The concentration of CO_2 is also approximately equivalent to a net heat input by direct firing of 86 kJ per cubic metre of outside air that enters the room per hour, or to a gross heat input of 27 W per cubic metre of outside air (which equates to 37 m^3 of outside air per kilowatt of gross heat input) that enters the room per hour.

9.6.2 Procedures

9.6.2.1 The CO/CO_2 ratio or CO and/or CO_2 readings should be recorded:

a) when the burner of the gas-fired appliance has been operating at the maximum rated input for 30 min;

b) when the reading is steady; or

c) when the reading is at an acceptable level (see Table 3 or the manufacturer's instructions, as applicable) and is decreasing.

Unless different instructions are specified by the manufacturer, readings should be taken from whichever of these occurs first.

NOTE The combustion performance (CO/CO_2 ratio) of non-domestic gas-fired appliances might be available to the operative although it is often the case that non-domestic equipment is commissioned and maintained using CO concentration and/or CO_2 (via O_2) concentration values obtained in the combustion products.

9.6.2.2 Where the CO/CO_2 ratio or CO and/or CO_2 readings are unacceptable (see Table 3 or the manufacturer's instructions, as applicable) then the appropriate action recommended in **8.6.2** should be followed.

9.6.2.3 Certain new components of the gas-fired appliance might be made from materials containing volatile compounds which need to be burned off before reliable CO and/or CO_2 measurements can be obtained. When a new component has been fitted, the gas-fired appliance should be operated at full rate and a combustion reading taken after 10 min. Where the reading is unacceptable or still rising, readings should be taken at 20 min intervals until a satisfactory stable level is reached or the level stabilizes at an unacceptable level. Where the level does not fall within 20 min, then a further inspection of the gas-fired appliance should be made to establish the cause of the high reading.

NOTE Examples of materials containing volatile compounds include ceramic fibres, metal components, insulation and adhesives.

9.6.2.4 Combustion performance readings should be taken both from the attached gas-fired appliance in the primary flue and at the discharge terminal from the fan dilution system.

9.7 MEV systems

9.7.1 General

MEV systems can be utilized in a similar way to thermal evacuation openings (see **A.4.2.1**), which use an electrically driven fan to extract stale air and combustion products and replace them with fresh cool air.

Where the mechanical system is intended to be part of a purpose-provided ventilation/extraction system to provide combustion air, or to extract combustion products from flueless space heating or gas-fired appliances, it should be interlocked. This should be checked prior to testing for CO and/or CO_2.

Some gas-fired appliances might incorporate a mechanical extraction fan within the chimney system that is used to overcome design limitations of excessive diameter, length or inaccessible chimney routes. In some cases the fan might be of a variable speed type to provide automatic adjustments for various wind speeds and weather conditions or burner flow rates. The fan should overcome the design resistances of the chimney. In all cases the chimney fan should be interlocked with the gas-fired appliance to shut it down in the event of fan failure.

Guidance regarding the fan/chimney suction required to overcome any resistance through an appliance heat exchanger should be requested from the manufacturer of the gas-fired appliance. When checking the combustion performance of a gas-fired appliance that incorporates a mechanical chimney fan, the equipment should be checked at maximum and minimum heat inputs and any intermediate settings that can be selected.

9.7.2 Additional checks for MEV systems

For MEV systems, the following additional checks should be made.

a) Check that the MEV fan is being supplied with electrical power.

b) Check that the fan is securely attached to the drive motor shaft.

c) Check that the fan blades are present and undamaged, and the direction of rotation is correct.

d) Check that the air filters are not blocked.

e) Check that the trip systems and/or safety interlocks are working correctly.

10 Domestic gas-fired appliances installed in non-domestic premises

10.1 General

The CO/CO_2 ratio of domestic gas-fired appliances installed in non-domestic premises should conform to the acceptable CO/CO_2 ratio stated in the manufacturer's instructions. Where the manufacturer's instructions are not available or no limit for an acceptable CO/CO_2 ratio is given, the CO/CO_2 ratio should be in accordance with Table 3. Where the manufacturer's instructions only provide a limit for CO_2, then the CO/CO_2 ratio should be in accordance with Table 3.

Where higher CO/CO_2 ratios than those listed in Table 3 are obtained or where a gas-fired appliance type is not included in Table 3, then advice should be sought from the gas-fired appliance manufacturer. The operative should also identify and rectify fault(s) causing poor combustion. Where the operative is unable to rectify the fault(s), they should refer to the GIUSP [11].

For domestic open-flued gas-fired appliances installed in non-domestic premises, a well-mixed representative sample of the combustion products can be obtained by positioning the tip of the sample probe at least 200 mm into the secondary flue. The open-ended sampling probe that is usually supplied with an analyser is often suitable to collect a thoroughly mixed and representative sample of the combustion products. However, where this type of probe is not available or flexible enough to gain sufficient access, it is recommended that the probe is open-ended and made from 6 mm outside diameter (OD) malleable metallic tubing approximately 500 mm in length.

10.2 Flueless

The installation should be checked to conform to the manufacturer's instructions.

NOTE The manufacturer's instructions are likely to include details such as room size, location, functional windows, permanent ventilation, draughts and labelling.

10.3 Open flue

10.3.1 The chimney, including any section in the roof space or void, should be checked for freedom from defects and for correct routing and size. Where a ridge terminal is fitted, the integrity of the adapter and its fixing bolts should be checked. The type and location of the terminal should also be checked. Where equipment needs to be removed for this to be done, it may be carried out after the initial tests have been completed.

NOTE For guidance on checking flues in voids see Gas Safe Register Technical Bulletin 008, Room-sealed fanned draught flue systems concealed within voids *[23].*

10.3.2 Where spillage or chimney flow problems are identified, ventilation to the room should be increased to determine whether the problem is related to inadequate ventilation.

10.3.3 External factors that could have an effect on chimney performance should be considered, for example:

a) topographical features such as hills and large trees, which under some weather conditions can have an adverse effect;

b) wind turbines;

c) short chimneys on single storey extensions;

d) excessive lengths of external fluepipe in exposed positions, which could be subject to cold temperatures.

10.3.4 The effect of a restricted air supply to both the combustion chamber area and the flue/draught diverter as a result of inadequate installation clearances should be considered.

10.3.5 The potential interaction between chimneys, particularly long masonry chimneys affecting short chimney pipe systems, and the effect of solid fuel appliance operation on an open-flued gas appliance should also be considered.

10.4 Room-sealed gas-fired appliances

10.4.1 Seals, fastenings and the chimney assembly should be checked to be correctly fitted.

10.4.2 The casing of the gas-fired appliance should be checked to be correctly fitted.

10.4.3 For a positive pressure gas-fired appliance, air disturbance should be checked around the casing using a match, taper or smoke generating device other than a smoke pellet.

NOTE Attention is drawn to the Gas Safe Register document, Industry guidance for the checking of case seals and the general integrity of room-sealed fan assisted positive pressure gas appliances *[17].*

10.5 Warm air heaters

10.5.1 With the exception of the kitchens, bathrooms and WCs, rooms with a warm air outlet should be checked for a return air path to the main collection area.

10.5.2 Where the gas-fired appliance is open-flued, the return air grille and the gas-fired appliance should be checked for a positive return air connection and the grille should be checked for freedom from obstructions such as clothing.

10.5.3 Where a flame picture is provided in the manufacturer's instructions it should be compared to the flames of the gas-fired appliance with the circulation fan running. Where the flames are disturbed, the heat exchanger, the positive return air connection and the integrity of the plenum and all ducting joints (particularly those within any heater compartment) should be checked.

*COMMENTARY ON **10.5.3***
In the absence of manufacturer's instructions regarding how to check the integrity of the heat exchanger, information can be found in the CORGI manual, Central Heating Wet and Dry *[21].*

Some warm air heaters are provided with a fanned air supply from a ventilated roof space or outside air to the return air duct or return plenum as described in BS 5864.

10.6 Fires

10.6.1 The chimney should be checked to be the correct size for the fire.

10.6.2 The catchment space should be examined for correct size, integrity and freedom from debris, and the base of the chimney and any fire surround checked to be correctly sealed.

10.6.3 Where the chimney includes precast blocks, a visual check should be carried out, if practicable. The visual check should confirm that the precast blocks are of the correct type for the fire, that they are correctly installed and that the joints are soundly made with no excessive mortar protrusions causing a restriction in the chimney. The minimum dimensions should be measured and the cross-sectional area of the chimney calculated. The size of the precast blocks used within the chimney should be checked to conform to the gas-fired appliance manufacturer's installation instructions. Where a size is not specified by the manufacturer, they should be contacted for advice.

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10.6.4 Any damper fitted should be removed or locked in the open position in a way that minimizes the possibility of blockage to the chimney.

10.6.5 The flue spigot and spigot restrictor should be checked for correct installation.

10.6.6 Any closure plate should be as specified by the manufacturer and sealed to the mounting surface.

10.6.7 The heat exchanger should be visually examined for signs of cracks and indication of leakage; for example, staining.

10.6.8 In the case of a fuel effect gas fire, the fuel bed should be visually examined to check that it has been assembled correctly in accordance with the appliance manufacturer's instructions.

10.7 Fire/back boilers and fire/back circulators

10.7.1 Catchment spaces should be examined for correct size, integrity and freedom from debris.

10.7.2 Checks should be carried out to ensure the following.

a) The flue product outlet connection to the back circulator fitted to an unlined chimney is constructed to prevent the entry of falling debris into the gas-fired appliance flue spigot or flue piece.

b) Any special flueing arrangements contained in the gas-fired appliance conform to the manufacturer's instructions.

c) The chimney is lined in cases where a back boiler has been fitted.

d) The liner fitted is either continuous from the gas-fired appliance to the terminal or, where a short length of either rigid or flexible flue pipe has been used to connect the appliance to the chimney liner via an appropriate adaptor:

   1) the flue pipe projects at least 150 mm into the liner; and

   2) the annular space between the pipe and the chimney liner is sealed in such a way that it does not restrict the flue pipe exit and the seal material does not fall into the back boiler enclosures.

e) The builder's opening is sealed from any duct constructed to accommodate pipe-work.

f) The back boiler/back circulator enclosure only has two openings: an entrance through and round the back of the fire and an exit via the chimney. Other openings should be sealed, in particular gaps/cracks inside the builder's opening (including any in or around any chair-brick), those between any surround and the builder's opening, those which exist in respect of an existing under-floor air supply, and those made for the passage of gas, water, chimney pipes and electric cables.

g) The ventilation duct has been suitably sized to accommodate the total of the maximum rated heat inputs of the combined fire/back boiler or fire/back circulator.

NOTE See BS 5440-2 for more information regarding the design, materials and arrangements of air vents and ducts.

10.8 Cookers

10.8.1 Cookers should be tested in accordance with BS 7967-2.

10.8.2 The cooker should be checked to be fitted in accordance with the manufacturer's instructions, where available, or BS 6172, particularly with regard to clearances from obstructions, for example, a shelf fitted directly above a high level grill. The location of any cooker hood or extract fan sited above or adjacent to the cooker/hob should be checked to be fitted in accordance with the manufacturer's instructions.

10.8.3 Flame patterns on burners should be checked. Particular attention should be given to:

a) flame impingement on the fret and/or fret distortion for grill burner designs that consist of a bar burner firing below a perforated fret;

b) grease spillage on the oven burner; and

c) aeration, damaged burner caps/flame retention components and venturi tube alignment for hotplate burners.

11 Post-testing

11.1 Post-testing operative actions

11.1.1 Where the operative identifies unsafe gas-fired appliance(s) or installations, they should provide the responsible person with accurate recorded results of tests, checks and investigations carried out. The operative should also provide guidance to the responsible person on the risk classification in accordance with the GIUSP [11].

11.1.2 The course of action taken should be in accordance with the GIUSP [11], wherever practicable. The operative should advise and provide assistance to the responsible person regarding such a course of action.

11.1.3 The operative should agree with the responsible person the actions that the operative is required to carry out to maximize gas safety. These actions should be based on the results of a risk assessment carried out in accordance with **5.4**. The operative should obtain a copy of their job documentation from the responsible person that records and authorizes the actions that they need to carry out.

*NOTE Basic safety principles and priorities are given in **5.1**.*

11.2 Reports

11.2.1 When investigations have been completed, the operative should leave the responsible person with a report that provides sufficient detail to enable them and the owner (where they are different individuals) to understand the nature of the tests carried out, the results, the status of relevant gas-fired appliances and remedial action(s) required.

11.2.2 A standard reporting format should be used to check that the necessary information is communicated to the responsible person.

11.2.3 Where the responsible person has not authorized the investigation of suspect gas-fired appliances, this should be documented.

11.2.4 Where other sources of CO and CO_2 are suspected, the operative should check that the responsible person and, where necessary, any other persons potentially affected (such as neighbours where it is suspected that the source of CO and CO_2 originates from a neighbouring property or premises) are aware of such concerns. These individuals should be advised to check that appropriate action to investigate and rectify the problem situation is carried out. Advice and information given by the operative should be documented.

11.2.5 Details of outstanding work or recommendations for additional items such as servicing arrangements and advice on the correct use of equipment should also be documented and left with the responsible person.

11.3 Completion and leaving the premises

11.3.1 Where spillage, leakage or build-up of CO and/or CO_2 is found (see **7.3.4**), every attempt should be made to rectify the problem(s) and leave the gas-fired appliance working safely. When any defect has been noted that could affect the effectiveness of the chimney, the supply of combustion air, the operating pressure or heat input of the equipment, or the safe functioning of the gas-fired appliance, the defect should be corrected at the time of the visit or, where this is not practicable, the GIUSP [11] should be referred to for guidance.

11.3.2 Following an evacuation, where hazardous levels of CO and/or CO_2 remain in the premises that are not attributable to gas appliances, the operative should either inform the responsible person to contact an appropriate authority such as the local Environmental Health Department, or else contact them directly themselves. The operative should also advise the responsible person that the property needs to remain evacuated until the appropriate authority advises otherwise.

11.3.3 Where an investigation has been carried out but no faults have been found that could have resulted in the suspected leakage of combustion products, the installation may be reinstated. However, where the gas-fired appliance has previously been investigated for suspected leakage but none found, the gas-fired appliance may be reinstated but further investigation and long term monitoring should be recommended to the responsible person. The responsible person should always be advised that although no sources of CO and/or CO_2 have been identified, when individuals feel unwell in the vicinity of the reinstated equipment, they should consult a doctor immediately.

*NOTE For information regarding the migration of CO, which can cause high readings of combustion products, refer to **A.3.2.3**.*

11.3.4 Regular servicing of all gas-fired appliances should be recommended to the responsible person, where such arrangements are not in place.

11.3.5 Where the responsible person does not have an electrical CO alarm fitted, they should be made aware of the potential contribution to safety, for all fuel-burning equipment, that such an alarm can make. However, it should be stressed that such alarms are to be regarded only as a back-up precaution and not as a substitute for proper installation and maintenance of equipment and chimneys.

NOTE For further information on electrical CO alarms in catering establishments, refer to the HSE document, CAIS 23 (Rev 1) [18].

Annex A (informative) Additional investigation considerations

A.1 General

When carrying out ambient air testing and combustion performance testing, it is important to consider factors that could affect the electronic portable combustion gas analyser readings.

These factors include:

a) the effects of other gases and vapours present in the vicinity of the gas-fired appliance on electronic portable combustion gas analysers;

NOTE 1 Commonly used mixtures for welding and flame cutting are oxygen and acetylene.

b) the processes and process equipment used in the vicinity of the gas-fired appliance;

*NOTE 2 In this instance it is essential to liaise with the responsible person on site (see **5.2**).*

c) the movement of CO and CO_2 in ambient air; and

d) air extraction, ventilation and circulation systems.

A.2 The presence of gases and vapours in the ambient air

A.2.1 Effects on the electronic portable combustion analyser

Electronic portable combustion gas analyser readings for CO and CO_2 can be affected by the presence of other gases and vapours through sensor cross-sensitivity. These can originate from sources such as commercial cooking activities or common commercial substances such as cleaning fluids, polishes and paints and can result in inaccurate readings.

The manufacturer's instructions for electronic portable combustion gas analysers conforming to BS EN 50379-3 (or BS 7927:1998 including Amendment 1) or BS 8494 (see **6.1.2** and **6.1.3**) should be referred to for guidance regarding which substances can interfere with the gas analyser operation or its reliability in the short or long term and the actions that can be taken to prevent inaccurate readings. Where no guidance is given, the manufacturer should be contacted and guidance requested.

A.2.2 Effects of industrial processes and chemicals on suspect gas-fired appliances and combustion performance

Airborne dusts, vapours, refrigerants and gases that are produced from industrial processes and chemicals can react with the combustion flame. They can affect the quantities and ratios of combustion products produced. They can also degrade to produce potentially harmful gases that corrode metal components such as heat exchangers, burners and combustion chambers. In situations where this could be problematic, the air supplied to the burner of the gas-fired appliance should be checked to be outside air, free from such contaminants as they could be the cause of excessive levels of CO and/or CO_2.

The production, forming and use of plastics, fibreglasses, resins and glues have been identified as being particularly problematic, as well as chemicals used in the printing, hairdressing and metal plating industries.

When in any doubt about the effects of industrial processes and chemicals, guidance should be sought from the responsible person, the gas-fired appliance manufacturer or the electronic portable combustion gas analyser manufacturer.

A.3 Air movement

A.3.1 Movement of CO and CO_2

Chimney and/or gas-fired appliance performance can be affected by CO and CO_2 that is circulated around the premises in a number of ways. It is important that the operative is aware of the following.

a) *Rising warm air and combustion products*. CO and CO_2 could be present in rooms other than those containing the fuel-burning equipment or chimney systems, especially in upper storeys, as a result of tracking through pipe ducts, suspended or mezzanine floors or false chimney breasts.

b) *Number of occupants within the premises*. Their movements can increase the levels of CO_2 and increase air circulation throughout the premises. In addition, any activities that they are undertaking can have an impact on the levels of CO and/or CO_2 measured in the ambient air.

c) *Adjacent properties and re-entry from chimney outlets*. Where high levels of CO and CO_2 are being produced on an adjacent property, or are being evacuated in an area where air movement makes them likely to enter the premises under investigation, they can alter the levels of CO and CO_2 on the premises under investigation. Extended chimneys and/or special chimney terminals on adjacent properties can therefore be problematic.

d) *Weather conditions*. High combustion performance ratio readings can occur from persistent elevated wind speeds preventing the safe discharge of combustion products from a terminal. High combustion performance ratio readings can also be the result of thermal inversion, which can occur in warm weather and which also prevents the safe discharge of combustion products from a terminal.

A.3.2 The dispersion and accumulation of CO in buildings from a faulty gas-fired appliance

A.3.2.1 General

When combustion products are discharged into a room, their temperature tends to be significantly higher than the ambient air temperature and as a result, they rise. On cooling, the density of the CO becomes similar to that of the other gases in the ambient air and mixing occurs. This also depends upon whether there is any thermal convection which can even out the temperature within a building and so facilitate gaseous mixing.

A.3.2.2 CO build-up from a faulty gas-fired appliance operating in a single room

A faulty space heater, for example a flueless heater with poor combustion or a gas fire with inadequate flueing, tends to cause CO to build up evenly between the floor and ceiling of the room within which the gas-fired appliance is operating.

Faulty gas-fired appliances that are not intended to heat the room in which they operate and that can generate CO from above floor level (for example, the hotplate of a cooker with poor combustion, a sink water heater left on for an excessive period or an open-flued wall-mounted boiler with inadequate flueing) tend to cause the CO concentration to rise more rapidly at and above the height at which CO is produced.

A.3.2.3 Migration of CO in a building

When CO flows into a room from a faulty gas-fired appliance, the greatest and most rapid build-up tends to occur within the room where the CO source is located. CO movement through the building usually follows even when any doors to the appliance room are closed. This migration to adjacent rooms on the same floor level often proceeds via gaps around the doors or through any open doorways. This results in a CO build-up within adjacent rooms that reflects the level of CO in the gas-fired appliance/source room.

It is important to realize that CO generated in one part of a building can also migrate to other more distant parts of the building and this can involve movement between individual properties in the same construction.

The movement of CO between floors can proceed in a number of different ways. CO movement from a gas-fired appliance room to an upper floor via a stairwell, for example, tends to cause CO to accumulate uniformly between floor and ceiling level in upstairs rooms. Migration of CO to floors at a lower level than the source can happen if thermal conditions outside the gas-fired appliance room promote mixing (although this process tends to take place less easily than the dispersion of hot buoyant combustion products to an upper floor). Such movement can frequently make the detection of CO particularly difficult in multi-occupancy and multi-storey buildings where CO produced at one location is able to move to another part of the building (for example across roof spaces, through other rooms, along ducting and via shared chimney systems).

It is also important to note that combustion products can migrate through a building through a faulty chimney. The rate at which CO moves around and the manner in which it builds up as a result depends on variables such as the type of opening(s) present that lead into another room (for example a hole or a small crack causing CO to flow low down or high up in the room), the temperature of the combustion products at this location, and the flow of air within that room (for example, the flow of air in a heated room will differ from that in an unheated room).

Ducted warm air systems can also provide routes for CO migration. Where a warm air installation is defective, it is possible for combustion products to enter the circulated air system and therefore become distributed throughout a property.

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A.4 Air extraction, ventilation and circulation systems

A.4.1 General

When taking ambient air readings in non-domestic premises, the ventilation system should be considered.

Full site investigation and testing should be carried out, when the build-up of CO_2 has levelled out and the ventilation systems are in normal day-to-day operation. Due regard should be given to the build-up of combustion products during this time and if at any time during the equilibrium period excessive levels of CO or CO_2 are recorded, the guidance given in Clause **5** should be followed.

In addition, any de-stratification fans, air distribution system or air distribution ductwork within the building or space to be tested should be put in normal operation.

Where other open-flued appliances are installed within the collection area or adjacent areas, consideration should be given to whether the circulation fan could interfere with their chimney performances.

A.4.2 Air extract and dilution methods

A.4.2.1 Thermal evacuation

Thermal evacuation utilizes openings or terminals situated in the roof structure, usually located above or adjacent to space heaters and/or gas-fired process appliances. This allows lower density warmer air to rise and escape, drawing cool outside air in through purpose-provided vents at low level or through natural building openings around doors and windows, for example.

Though it can be possible to close these openings in order to regulate the building temperature, they should be interlocked to maintain the thermal evacuation in the open position while the gas-fired appliance is in operation.

A.4.2.2 Natural air changes

The building can utilize natural air change rates within the structure to promote sufficient dilution of combustion products from flueless space heating or gas-fired process appliances and maintain safe operation. In this case the system relies upon enough cool outside air being drawn into the building through openings around windows and doors or through the frequent opening and closing of doors, windows and roller shutters, for example. In this situation, additional ventilation grilles or openings might still be necessary, but this depends upon the design air change rate of the building.

A.5 Ambient air testing

A.5.1 Investigating suspect gas-fired radiant heating/direct-fired air space heating equipment

When investigating suspect gas-fired radiant heating, or direct-fired air space heating appliances, it might be more appropriate to take ambient air readings within the vicinity of the suspect gas-fired appliance following a visual inspection for obvious defects.

Consideration should be given to checking readings at the maximum heat output rate and minimum heat output rate (where applicable). Consideration should also be given to checking readings across the full range of air intake and/or recirculation settings.

A.5.2 Compressed CO_2 for processes or special effects

When testing ambient air, compressed CO_2 used in the vicinity of gas-fired appliances under test should be noted, for example in drinks dispensers in pubs and bar cellars. Leakages from cylinders can occur and affect ambient air readings. Solid CO_2 (known as dry ice) is often used for stage performance special effects and for the temporary rapid freezing of water pipework; where present, this can also affect ambient air readings.

A.5.3 Laundry and commercial catering equipment and other industrial process equipment

A.5.3.1 Laundry equipment

When checking or testing the ambient air within a laundry, the operative should check that all appliances within the laundry under consideration are operating under full laundry load conditions. The operative should also consider the type of ventilation and extract system utilized in order to judge its effectiveness based upon the readings taken.

A.5.3.2 Catering equipment

When checking or testing ambient air within catering installations, the operative should check that gas-burning, ventilating and extract equipment that could affect the area under consideration is being operated under its normal working conditions.

NOTE Further guidance on the specific requirements for gas-fired appliances installed in catering premises can be found in the HSE information sheets CAIS No 23 (rev. 1) Gas safety in catering and hospitality *[18] and CAIS 10 (rev. 1)* Ventilation of kitchens in catering establishments *[22].*

A.5.3.3 Hand-held and bench blowlamps and burners

When carrying out ambient air tests within the vicinity of blowlamps or burners (either hand-held or positioned on work benches), higher concentrations of CO_2 and CO might be registered than are considered acceptable for fixed gas-fired appliances. However, these are generally short-term readings and as such, recommended time-weighted exposure levels and the need for sufficient ventilation and/or extraction within the workspace still apply.

A.5.3.4 Ambient air around furnaces and carbon rich process flames

Some furnaces and gas flame processes specifically produce incomplete combustion in order to create the chemical atmosphere required for a specific reaction to take place. This is the case with ceramic kilns in schools. For this type of gas-fired appliance, guidance should be sought from the manufacturer, responsible person or plant operator as to the expected combustion performance during acceptable and safe operation. Guidance should also be sought from these sources regarding

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any systems of work in place or additional safety controls designed to prevent the build-up or escape of combustion products or emission of gases into work areas.

A.5.3.5 Drying and curing

Some industrial processes, for example those in the pottery industry, use the heated space outside of normal working hours to dry or cure moulds and castings. Once the heated space has been prepared or filled, it is evacuated and closed off to employees. Ventilation and extract systems are closed and a maximum heating load is applied to the space.

After a specified time period the heating load is removed, the ventilation and extract switched back on and the space adequately ventilated before employees are permitted access to the heated space. Ambient air testing carried out during this curing process might record high levels of CO_2 or even CO within the heated space. In such instances, there should be a safe system of work in place to prevent employees from entering the heated space during the curing process.

A.5.3.6 Generators, compressors, engines, forklift trucks and vehicles

Fixed generators, compressors and engines might be found in operation within non-domestic premises and plant rooms. This type of equipment should be considered as the possible source of high levels of CO and CO_2 in the ambient air. Prior to combustion product testing or ambient air testing, the effects of such equipment on the supply of combustion air and the chimney performance of any gas-fired appliance in the vicinity should be considered and included in the final report.

Large premises such as warehouses or commercial garages might use fork lift trucks or have other vehicles on the premises that can emit CO and CO_2 directly into the ambient air within the building, affecting background ambient levels or atmosphere readings during the course of testing. In order to fully investigate the combustion performance of gas-fired appliances, vehicles should be prevented from entering the area being tested until the testing has been completed. A suitable length of time should be allowed for the dissipation of any residual CO or CO_2 in the ambient air that has been emitted from passing vehicle exhausts, before testing begins.

A.5.3.7 Multiple chimney and common chimney systems

It is common in non-domestic premises to find modular boiler systems that consist of a number of identical heating modules fitted with atmospheric or forced draught burners, sharing the same heating load and joined to a common natural draught chimney header.

There might be multiple common chimney systems within a single plant room/space or a number of individually flued gas-fired appliances, or a combination of both. The operative needs to be aware of the interaction and effects that gas-fired appliances or chimney systems can have on the combustion or chimney performance of other gas-fired appliances attached to the same common chimney or within the same space.

Individual gas-fired appliances with multiple chimney and common chimney systems should be tested at their maximum and minimum heating loads, where practicable, as well as at any other available customer-adjustable heat load settings.

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Individual gas-fired appliances should also be tested in combination with other adjacent gas-fired appliances to check that they do not adversely affect the combustion performance of the installation as a whole. Where there is a common chimney, it is important to check that it is capable of removing the total volume of combustion products from all of the attached equipment at full heating load.

A.6 Fan dilution systems

A.6.1 Air heaters with recirculation

For air heaters installed with recirculated air, the CO_2 concentration in the heated air should be measured under conditions of maximum heat input and maximum recirculation, as specified in the manufacturer's instructions.

A.6.2 Air heaters supplied with outside air

For air heaters installed so that the air passing over the burner is outside air, the CO_2 concentration in the heated air should be measured under conditions of maximum heat input, at the minimum heat input, and at all other available outside air supply rate settings.

A.6.3 Air heaters intended for intermittent use

Air heaters intended for intermittent use, such as door curtain heaters, should not be operated continuously when CO and/or CO_2 testing is undertaken.

A.6.4 Multiple burner radiant tube systems

Some herringbone or multiple burner radiant tube systems use a chimney duct system, or in some cases an air inlet duct/fan with an extract chimney fan located on the end of the chimney system that terminates outside of the building. These systems incorporate individual flue gas test points to check the combustion of individual burners and a lockable damper that can be used to balance the pull of the extract fan evenly to the tubes connected to the system.

To determine the recommended CO and CO_2 levels for individual burner modules and for the output from the exhaust fan for a multiple burner system, it might be necessary to refer to the manufacturer's instructions.

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Annex B (informative) The effects of CO and CO_2 on human beings

B.1 The effects of CO on human beings

Table B.1 gives a general guide to the effects of CO on adult human beings.

Table B.1 **Health effects of CO on adult human beings**

CO %	Parts per million (ppm)	Effects on adults	Saturation of CO in blood stream %
0.01	100	Slight headache in 2–3 h	13
0.02	200	Mild headache, dizziness, nausea and tiredness after 2–3 h	20–30
0.04	400	Frontal headache and nausea after 1–2 h; risk to life if over 3 h exposure	36
0.08	800	Severe headaches, dizziness, convulsions within 45 min; unconsciousness and death possible after 2–3 h	50
0.16	1 600	Headaches, dizziness and nausea within 20 min; collapse, unconsciousness and death possible within 1–2 h	68
0.32	3 200	Headache, dizziness and nausea within 5–10 min; possible death after 15 min	70–75
0.64	6 400	Severe symptoms within 1–2 min; death within 15 min	80
1.28	12 800	Immediate symptoms; death within 1–3 min	85–90

B.2 Health effects of CO_2

Table B.2 gives a general guide to the health effects of different concentrations of CO_2 in ambient air and guideline exposure limits.

Table B.2 **Health effects of CO_2 in ambient air and guideline exposure limits**

Description	Concentration (ppm)	CO_2 %
Typical background concentration in outdoor ambient air	300–400	0.03–0.04
Symptoms sometimes reported after exposure to levels of CO_2 in ambient air:		
Concentrations typical of occupied indoor spaces with good air exchange	350–1 000	0.035–0.1
Complaints of drowsiness and poor air	1 000–2 000	0.1–0.2
Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea might be present	2 000–5 000 [A)]	0.2–0.5
Potential for serious oxygen deprivation resulting in permanent brain damage, coma and even death (Symptoms appear after a very short exposure time)	≥ 40 000	4.00
Workplace exposure limits (WELs): [B)]		
Long term exposure limit (8 h time-weighted average)	5 000	0.5
Short term exposure limit (15 min reference period)	15 000	1.5

[A)] Levels can reach 2 000 ppm in overcrowded rooms.

[B)] See the HSE guide EH40, *Workplace exposure limits: containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended)* [16].

B.3 Human respiration and CO_2

The body requires oxygen for the production of energy at a rate approximately proportional to metabolic rate. This in turn is proportional to body surface area and to activity level. Expired air contains about 16% oxygen and 4% (40 000 ppm) CO_2 and is fully saturated with water vapour.

Human beings, in good health, can adapt to a range of oxygen concentrations, with a minimum concentration, at typical ambient pressures, of approximately 12%. The main limiting factor is, in practice, the build-up of CO_2. Although higher levels of CO_2 can be tolerated with no serious health effects, a useful guide is the occupational exposure limit of 0.5% (5 000 ppm). Air flow rates necessary to accomplish this and a lower concentration of 0.25% (2 500 ppm) CO_2 are given in Table B.3 for a range of activity levels.

Table B.3 **Fresh air requirement values for respiration**

Activity (adult male)	**Metabolic rate (M)**	**Flow rate to maintain room CO_2 at given level assuming 0.04% (400 ppm) CO_2 in fresh air**	
		0.5% CO_2	**0.25% CO_2**
	W	L/s	L/s
Seated quietly	100	0.8	1.8
Light work	160–320	1.3–2.6	2.8–5.6
Moderate work	320–480	2.6–3.9	5.6–8.4
Heavy work	480–650	3.9–5.3	8.4–11.4
Very heavy work	650–800	5.3–6.4	11.4–14.0

NOTE 1 These values are based upon a production rate of CO_2 of 0.000 04 M L/s per person, where M is the metabolic rate in watts.

NOTE 2 This table was sourced from BS 5925:1991+A1.

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Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

BS 5864, *Installation and maintenance of gas-fired ducted air heaters of rated input not exceeding 70 kW net (2nd and 3rd family gases) – Specification.*

BS 5925:1991+A1:1995, *Code of practice for ventilation principles and designing for natural ventilation.*

BS 6173, *Specification for installation and maintenance of gas-fired catering appliances for use in all types of catering establishments (2nd and 3rd family gases).*

BS 6230, *Specification for installation of gas-fired forced convection air heaters for commercial and industrial space heating (2nd and 3rd family gases).*

BS 6896, *Specification for installation of gas-fired overhead radiant heaters for industrial and commercial heating (2nd and 3rd family gases).*

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* (withdrawn).

BS EN 13410, *Gas-fired overhead radiant heaters. Ventilation requirements for non-domestic premises.*

PD CEN/TR 1749, *European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types).*

Other publications

[1] GREAT BRITAIN. The Reporting of Injuries, Diseases and Dangerous Occurences Regulations 1995. London: The Stationery Office Limited.

[2] GREAT BRITAIN. The Gas Safety (Management) Regulations 1996. London: The Stationery Office Limited.

[3] INSTITUTE FOR ENVIRONMENT AND HEALTH. *Indoor air quality in the home: Nitrogen dioxide, formaldehyde, volatile organic compounds, house dust mites, fungi and bacteria (Assessment A2)*. Norwich: Page Bros, 1996. [2)]

[2)] Available as a free download from the Cranfield University website, www.cranfield.ac.uk.

[4] HEALTH AND SAFETY EXECUTIVE. *Five steps to risk assessment* (Revision 2). INDG 163. London: HSE Books, 2006. [3)]

[5] GREAT BRITAIN. The Gas Safety (Installation and Use) Regulations 1998. London: The Stationery Office Limited.

[6] HEALTH AND SAFETY COMMISSION. *L56 Safety in the installation and use of gas systems and appliances. Gas Safety (Installation and use) Regulations 1998. Approved code of practice and guidance.* London: HSE Books, 1998. [3)]

[7] GREAT BRITAIN. The Gas Safety (Installation and Use) Regulations 1994, as amended and applied by the Gas Safety (Application) Order (Isle of Man)1996. London: The Stationery Office Limited.

[8] GREAT BRITAIN. The Gas Safety (Installation and Use) Regulations (Northern Ireland) 2004. London: The Stationery Office Limited.

[9] GUERNSEY. The Health and Safety (Gas) (Guernsey) Ordinance 2006. London: The Stationery Office Limited.

[10] HEALTH AND SAFETY COMMISSION. *Standards of training in safe gas installation. Approved code of practice* (COP20). London: HSE Books, 1996. [3)]

[12] GREAT BRITAIN. The Control of Substances Hazardous to Health Regulations 2002. London: The Stationery Office.

[13] HEALTH AND SAFETY COMMISSION. *The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved code of practice and guidance.* London: HSE Books, 2005. [3)]

[14] WORLD HEALTH ORGANIZATION. *Environmental Health Criteria 213. Carbon monoxide*, second edition. Geneva: WHO, 1999.

[15] GREAT BRITAIN. The Health and Safety at Work etc. Act 1974. London: The Stationery Office.

[16] HEALTH AND SAFETY EXECUTIVE. EH40: *Workplace exposure limits: Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended)*. London: HSE Books, 2005.

[17] GAS SAFE REGISTER. Technical Bulletin 006. *Industry guidance for the checking of case seals and general integrity of room-sealed fan assisted positive pressure gas appliances*. Basingstoke: Capita Gas Registration and Ancillary Services Ltd, 2009. [4)]

[18] HEALTH AND SAFETY EXECUTIVE. Catering Information Sheet No. 23: *Gas safety in catering and hospitality*. Revision 1. London: HSE Books, 2007. [3)]

[19] GREAT BRITAIN. The Clean Air Act 1993. London: The Stationery Office Limited.

[3)] Available as a free download from the HSE website, www.hse.gov.uk/pubns or through mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA.

[4)] Available as a free download from the Gas Safe Register website, www.gassaferegister.co.uk.

[20] INSTITUTION OF GAS ENGINEERS AND MANAGERS. IGE/UP/10, *Installation of flued gas appliances in industrial and commercial premises.* Loughborough: IGEM.

[21] CORGI. *Central heating wet and dry*. Third edition. Basingstoke: CORGI, 2007. [5)]

[22] HEALTH AND SAFETY EXECUTIVE. Catering Information Sheet No.10: *Ventilation of kitchens in catering establishments*. Revision 1. London: HSE Books, 2007. [6)]

[23] GAS SAFE REGISTER. Technical Bulletin 008. *Room-sealed fanned draught flue systems concealed within voids*. Basingstoke: Capita Gas Registration and Ancillary Services Ltd, 2009. [7)]

[24] GAS SAFE REGISTER. Technical Bulletin 021. *Measuring combustion performance to satisfy the requirements of the Gas Safety (Installation and Use) Regulations 1998 – Certificate of Exemption No. 1 of 2008*. Basingstoke: Gas Safe Register, 2009. [7)]

5) Available to order from CORGI*direct*, 4 Elmwood, Chineham Business Park, Crockford Lane, Basingstoke, Hampshire RG24 8WG, tel. 0800 915 0490.

6) Available as a free download from the HSE website, www.hse.gov.uk/pubns or mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA.

7) Available as a free download from the Gas Safe Register website, www.gassaferegister.co.uk.

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