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Specification for installation and maintenance of gas fired forced convection air heaters for commercial and industrial space heating (2nd and 3rd family gases)

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 July 2011. It was prepared by Subcommittee GSE/30/-/14, *Forced convection air heaters for commercial and industrial space heating (60 kW–2 MW)*, under the authority of 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 to its secretary.

Supersession

This British Standard supersedes BS 6230:2005, which is withdrawn.

Information about this document

This British Standard allows manufacturers' instructions to specify a method of installation, testing, commissioning or maintenance which differs in points of detail from this standard. This reference to manufacturers' instructions is allowed only where it results in at least an equivalent level of safety. In such circumstances, it is important that the manufacturer's instructions are followed.

In particular, attention is drawn to the following regulations.

a) The Gas Appliances (Safety) Regulations [1]. This British Standard only applies to appliances falling within the scope of these regulations.

b) The Gas Safety (Installation and Use) Regulations 1998 [2].

These control all aspects of the ways in which gas-fired appliances and systems may be installed, maintained and used, mainly in domestic and commercial premises, and the classes of persons who may undertake gas work.

NOTE 1 These regulations currently do not apply to industrial premises, except those parts used for domestic purposes and sleeping accommodation.

- *Gas Safety (Installation and Use) Regulations 1998 [2], as amended and applied by the Isle of Man Gas Safety (Application) Order 1996 [3].*
- *Gas Safety (Installation and Use) (Northern Ireland) Regulations 2004 [4].*
- *Health and Safety (Gas) (Guernsey) Ordinance 2006 [5].*

NOTE 2 Legislation can vary nationally or under local authorities. Information and advice can be obtained from regulating authorities such as the HSE, the Environment Agency and local authorities. Further advice can be sought, for example, from the relevant professional bodies and industry associations.

c) The Building Regulations (for the appropriate legislative region) [6], [7], [8].

NOTE 3 These control work carried out in the construction of new buildings or the extension and/or refurbishment of existing buildings. Detailed advice for England and Wales is given in approved documents [9], [10] and for Northern Ireland, in technical booklets [11, 12]. The Building Scotland Regulations 2010 [8] are accompanied by methods that are deemed to satisfy them.

d) The Water Supply (Water fittings) Regulations 1999 [13].

e) The Health and Safety at Work etc. Act 1974 [14].

f) The Electricity at Work Regulations 1989 [15].

Presentational conventions

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

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.

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1 Scope

This British Standard specifies the installation requirements for direct and indirect gas-fired forced convection air heaters for space heating that are designed for commercial or industrial applications and to which The Gas Appliances (Safety) Regulations 1995 [1] apply.

This British Standard applies to the installation and maintenance of appliances that are designed to utilize gases of Group H of the 2nd family (e.g. natural gas), gases of Group P of the 3rd family (e.g. propane) as well as gases of Group B of the 3rd family (e.g. butane) when supplied under the conditions of the third family pressure couple (see BS EN 437:2003+A1:2009).

NOTE 1 This British Standard does not specifically cover LPG/air for which additional requirements might be necessary.

This British Standard applies to the installation of direct gas-fired air heaters within the scope of BS EN 525:2009 and to indirect gas-fired forced convection air heaters within the scope of BS EN 621:2009, BS EN 1020:2009 and, where appropriate, BS EN 1196:1998. These standards cover air heaters having a net heat input not exceeding 300 kW. This standard also applies to the installation of direct gas-fired air heaters within the scope of BS 5990:2006 and to indirect gas-fired forced convection air heaters within the scope of BS 5991:1998. These standards cover air heaters having a gross heat input greater than 330 kW but not exceeding 2 MW (1.8 MW net).

NOTE 2 For the purposes of this British Standard, installation includes design, inspection and commissioning. It is recognized that each of the tasks can be performed at the same time by different persons.

NOTE 3 The ratio of gross to net heat input is approximately 1.11:1 for Group H (natural gas), 1.09:1 for Group P (propane) and 1.08:1 for Group B (butane).

NOTE 4 The ventilation rates in cm^2/kW of heat input given in this British Standard are based on the net calorific value.

This British Standard also applies to air heaters designed to supply make-up air, door curtain heaters, transportable air heaters and heat exchange modules (i.e. air heaters without a main air movement fan) where such heat exchange modules are used in environmental non-process applications such as air handling units. It also covers installation of heaters in areas where petroleum or other flammable heavier-than-air vapours can be present (see **5.1.2**).

It does not include the safety requirements for installation where flammable dusts, toxic gases or flammable lighter-than-air gases might be present in significant quantities.

NOTE 5 In such cases it is important that liaison takes place with the Health and Safety Executive.

This British Standard does not apply to the installation of air heaters to which The Gas Appliances (Safety) Regulations 1995 [1] apply, or that are designed for the sole use in domestic premises.

2 Normative references

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

BS 476-20, *Fire tests on building materials and structures – Part 20: Method for determination of the fire resistance of elements of construction (general principles)*

BS 476-21, *Fire tests on building materials and structures – Part 21: Methods for determination of the fire resistance of loadbearing elements of construction*

BS 476-22, *Fire tests on building materials and structures – Part 22: Methods for determination of the fire resistance of non-loadbearing elements of construction*

BS 476-23, *Fire tests on building materials and structures – Part 23: Methods for determination of the contribution of components to the fire resistance of a structure*

BS 5925, *Code of practice for ventilation principles and designing for natural ventilation*

BS 5990:2006, *Specification for direct gas-fired forced convection air heaters with rated heat inputs greater than 330 kW but not exceeding 2 MW for industrial and commercial space heating – Safety and performance requirements (excluding electrical requirements) (2nd family gases)*

BS 5991:2006, *Specification for indirect gas-fired forced convection air heaters with rated heat inputs greater than 330 kW but not exceeding 2 MW for industrial and commercial space heating – Safety and performance requirements (excluding electrical requirements) (2nd family gases)*

BS 6501-1, *Metal hose assemblies – Part 1: Guidance on the construction and use of corrugated hose assemblies*

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

BS EN 437:2003+A1:2009, *Test gases –Test pressures – Appliance categories*

BS EN 525:2009, *Non-domestic direct gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300 kW*

BS EN 621:2009, *Non-domestic gasfired forced convection air heaters for space heating not exceeding a net heat input of 300 kW, without a fan to assist transportation of combustion air and/or combustion products*

BS EN 1020:2009, *Non-domestic forced convection gas-fired air heaters for space heating not exceeding a net heat input of 300 kW incorporating a fan to assist transportation of combustion air or combustion products*

BS EN 1196:1998, *Domestic and non-domestic gas-fired air heaters – Supplementary requirements for condensing air heaters*

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

BS EN 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

BS EN ISO 10380, *Pipework – Corrugated metal hoses and hose assemblies*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN 525:2009, BS EN 621:2009, BS EN 1020:2009, BS EN 1196:1998, BS 5990:2006, BS 5991:1998 and the following apply.

3.1 condensing appliance
air heater in which, under normal operating conditions, the water vapour in the combustion products is totally or partially condensed in order to make use of the latent heat in the water vapour for heating purposes

3.2 damper
device to regulate, direct or stop the flow of gases or fluid through an opening or duct

3.3 direct gas-fired air heater
forced convection air heater in which the products of combustion mix with the heated air being supplied to the heated space

3.4 enclosure
space in which an air heater(s) is installed which is not large enough to permit access for work other than maintenance

3.5 forced convection air heater
appliance that provides space heating from a single source by distributing heated air by means of an air-moving device, either through ducting or directly into the heated space

3.6 grille
non-closable fitment for an opening through which air passes

3.7 hazardous area
space in which explosive gas-air mixtures are present or are expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus and fuel-fired appliances

NOTE See BS EN 60079-10-1 which also defines hazardous areas.

3.8 indirect-fired air heater
forced convection air heater in which the products of combustion are separately vented and do not mix with the heated air being supplied to the heated space

3.9 plant room
room which houses plant or machinery including air heaters

3.10 plenum chamber
chamber for receiving air before delivery to a heated space or a combustion system

3.11 recirculation air
air returned to a forced convection air heater from the space being heated and expressed as a percentage of the total air delivered by the heater, under the same temperature conditions

3.12 transportable direct-fired air heater
trolley or skid-mounted direct-fired forced convection air heater designed to operate with a maximum air temperature rise through the appliance of up to 55 K

4 Selection of equipment and pre-installation

4.1 Exchange of information and planning

4.1.1 General

*COMMENTARY ON **4.1.1***

At the time of publication, the body with HSE approval to operate and maintain a register of businesses who are "members of a class of persons" is the Gas Safe Register.

Persons deemed competent to carry out gas work are those who hold a certificate of gas safety competence acceptable to Gas Safe Register, which includes (without limitation) the National Accredited Certification Scheme for Individual Gas Fitting Operatives and the Gas Services S/NVQ that has been aligned with the National Accredited Certification Scheme. However, some ACOP certification for industrial installations might continue for some time.

Persons carrying out design, installation, commissioning, servicing or maintenance associated with and/or impacting on "gas work", "electrical installation", "drainage" or "ventilation provision" for warm air heating appliances shall be competent.

NOTE 1 The qualifications which persons need to have to be deemed competent to carry out gas work relevant to this British Standard are given in Table 1.

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.

NOTE 2 The statutory regulations, registration bodies and approval bodies applicable to Great Britain, the Isle of Man, Northern Ireland and Guernsey are given in Table 2.

Table 1 **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 HSP 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) [16].

4.1.2 Design considerations

The design shall be such that the installation is in accordance with the heater manufacturer's instructions.

NOTE 1 In case of doubt, contact the heater manufacturer.

Table 2 **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 [2]
Isle of Man	Gas Safe Register	Health and Safety Inspectorate (HSWI)	Gas Safty (Installation and Use) Regulations 1994, as amended and applied by the Gas Safety (Application) Order 1996 [3]
Northern Ireland	Gas Safe Register	Health and Safety Executive Northern Ireland (HSENI)	Gas Safety (Installation and Use) (Northern Ireland) Regulations 2004 [4]
Guernsey	Gas Safe Register	Health and Safety Executive for the States of Guernsey [HSE (Guernsey)]	Health and Safety (Gas) (Guernsey) Ordinance 2006 [5]

Persons who design the system or installation shall have a knowledge and understanding of the standards and regulations that apply to ensure that the completed plans produce a safe and satisfactory installation.

Those concerned with the design, installation and operation both at the planning stage and during the execution of work, shall work in collaboration with each other and take the following matters into account when carrying out the work:

a) type of building and form of construction;

b) sizes and purposes of rooms and working areas;

c) size, height and route of flue (if any) and the position of termination, including the possible consequences of any pluming, together with the materials of construction [1)];

d) provision of adequate air for combustion and ventilation;

e) assessment of heat losses and heat gains;

f) gas pressures and the availability of supplies;

g) electrical supplies;

h) liaison with fire insurers;

i) liaison with building owner/operator;

j) transmission of noise and vibration;

k) any hazardous area classification of the system's location;

l) the position of any drains for condensate.

[1)] Guidance on chimney and flue design is given in Appendix 3 of IGE /UP/10, Part 1 [17].

NOTE 2 Attention is drawn to statutory regulations and local byelaws, e.g. Building Regulations Approved Document L [18] and Local Air Quality Management Schemes.

Designers shall make customers aware, by providing them with the following list in writing, that it is the customer's responsibility to ensure that:

1) the local authority is consulted with regard to planning application requirements;
2) the fire authority and/or the enforcing authority under the Health and Safety at Work etc. Act 1974 [14], as appropriate, is consulted in respect of fire precautions;
3) the fire insurers are notified of any proposed changes in the means of heating;
4) the responsible gas conveyor is advised of the proposed installation of any gas booster or compressor which is either part of the appliance, or an addition to it;
5) the gas conveyor is consulted to ensure that the gas service is suitable to supply all of the gas to the complete installation at the correct pressure, including any existing load.

NOTE 3 Main contractors might need to draw their customers' attention to 1), 2), 3), 4) and 5).

4.1.3 Environmental considerations

Consideration and planning shall be agreed for the following areas.

a) Disposal/recycling of existing appliances and systems materials to be removed.
b) Disposal/recycling of new appliance and system components packaging.
c) Minimization of energy usage through appliance selection.
d) Minimization of harmfull emissions discharge.

4.2 Selection of air heaters

4.2.1 General

The operative shall ensure that the heater or multi-burner system for installation carries a CE mark, and is supplied with installation, maintenance and user instructions.

NOTE 1 Attention is drawn to the EC unit verification procedures in The Gas Appliances (Safety) Regulations 1995 [1].

The air heater shall only be connected to and supplied with the gas for which it was designed.

The installer shall ensure that the air heater is correctly adjusted in accordance with the manufacturer's instructions. Conversion to another gas, if necessary, shall be carried out strictly in accordance with the air heater manufacturer's instructions, using the manufacturer's supplied kit of parts.

The air heater shall only be fitted with external control devices of a type recommended by the air heater manufacturer. In case of doubt, the air heater manufacturer shall be consulted.

NOTE 2 Attention is drawn to HSE publication L56 [19].

In particular the installer shall ensure that the air heater and the packaging, if any, are marked with at least the following:

a) the letters "GB";

b) the type of gas and the pressure of utilization indicated as follows:

1) "G20 – natural gas – 17.5 mbar (or 17.5–20 mbar)" for an air heater adjusted for natural gas;

2) "G31 – propane – 37 mbar (or 50 mbar)" for an air heater adjusted for propane;

3) "G30 – butane – 29 mbar (or 28–30 mbar)" for an air heater adjusted for butane. This identification only applies when a category I_{3+} (or category II_{2H3+}) air heater, which is capable of utilizing butane and propane at different pressures, is adjusted for butane use.

NOTE 3 The data plate of a CE marked air heater will carry one of the following designations CAT: I_{2H} , I_{3P}, I_{3+}, II_{2H3P} or II_{2H3+} to identify the appliance category.

NOTE 4 Full details on the appliance category scheme are given in BS EN 437.

In all, four items of information shall be given, which, dependent on the appliance or system category and the appliance or system adjustment or state of conversion, shall be one of the alternatives listed in Table 3.

The installer shall check the data provided with the air heater to confirm that the air heater is appropriate for the installation, and shall confirm the basis on which the nominal heat input, or heat input rating, is quoted, i.e. gross or net.

NOTE 5 The ratio of gross to net heat input is approximately 1.11:1 for group H (natural gas), 1.09:1 for group P (propane) and 1.08:1 for group B (butane).

NOTE 6 Further information on the labelling of gas appliances is given in CR 1472:1997.

Table 3 **Air heater categories/adjustment for UK gas supply conditions**

Alternatives [A)]	Country code	Type of gas	Gas pressure [B)]	Air heater category
			mbar	
a)	GB	G 20, natural gas	17.5 or 17.5 to 20	I_{2H}
b)	GB	G 20, natural gas	17.5 or 17.5 to 20	II_{2H3P} or II_{2H3+} (when adjusted to use natural gas)
c)	GB	G 31, propane	37 or 50	I_{3P} or II_{2H3P} (when adjusted to use propane)
d)	GB	G 31, propane	37	I_{3+} or II_{2H3+} (when adjusted to use propane)
e)	GB	G 30, butane	29 or 28 to 30 [C)]	I_{3+} or II_{2H3+} (when adjusted to use butane)

[A)] If the information on the appliance, its packaging or the data plate is not in accordance with alternatives a), b), c), d) or e), or if there is any doubt about the suitability of the air heater for a particular gas, the appliance manufacturer should be consulted prior to installation.

[B)] If the gas pressure is not as indicated in Table 3, the gas conveyor should also be consulted prior to installation.

[C)] Appliances in categories I_{3+} or II_{2H3+}, when adjusted for butane, could be used without adjustment at the specified supply pressures of 28 mbar to 30 mbar.

4.2.2 Indirect gas-fired air heaters

4.2.2.1 General

Products of combustion from indirect-fired heaters shall discharge into a flue which terminates outside the building (see **5.10**).

Where vapours or gases or airborne dusts are present in the air which degrade into components that are potentially damaging to the appliance:

a) when passed through the combustion zone of a flame; and, possibly

b) as a result of heat transmitted through the heat exchanger,

all air supplied to the burner and, if necessary, to the heat exchanger shall be outside air that is free from such contaminants.

4.2.2.2 Condensing appliances

*COMMENTARY ON **4.2.2.2***

The manufacturer's installation instructions describe any particular requirements for the condensing air heater, e.g. a means for the disposal of condensate.

Condensing air heaters shall be installed in accordance with the manufacturer's instructions, paying particular attention to any instructions concerning the management of condensate, which might have implications on the siting of the appliance and/or its flue terminal.

When siting a condensing air heater, early consideration shall be given to the following.

a) The siting of any flue terminal.

- Condensing air heaters have a tendency to form a plume of water vapour from the flue terminal. The terminal shall be sited such that the wet combustion products are unlikely to cause damage or nuisance. The effect of wind conditions and the dispersal of the plume relative to adjacent wall surfaces, openable windows and neighbouring buildings shall be considered.

b) The positioning and termination of the condensate drain pipe.

- All connecting drainage pipework should have a fall of at least 2.5 ° to the horizontal or approximately 50 mm per metre of pipe run.

NOTE 1 If the drainage pipe has a run externally, it is recommended that the pipe is insulated to protect against frost. It should be noted that the connection of a condensate pipe to a drain might be subject to local building controls.

NOTE 2 Preferably the condensate pipe should run and terminate internally to a soil and vent stack or a waste pipe. Alternatively, the condensate can be discharged into the rainwater system or a purpose-made soakaway, but only if a combined foul storm water system is used.

c) The choice of condensate drainage pipe.

- The condensate drainage pipe shall be made from standard drain pipe material, e.g. polyvinyl chloride (PVC), unplasticized polyvinyl chloride (PVC-U), acrylonitrile-butadiene-styrene (ABS), polypropylene polypropene (PP) or cross-linked polyvinyl chloride (PVC-C). Any internal pipework shall be of a diameter specified in the air heater manufacturer's instructions. Any external pipework shall be kept to a minimum to avoid freezing and should have a diameter of not less than 22 mm.

4.2.3 Direct gas-fired air heaters

4.2.3.1 General

4.2.3.1.1 Where vapours or gases or airborne dusts are present which degrade to products that are potentially harmful to health when passed through the combustion zone of a flame, all air to the burner shall be outside air free from such contaminants. Recirculation, if practised in such circumstances, shall be downstream of the burner combustion zone.

NOTE 1 See HSE publication EH40 [20].

NOTE 2 In some applications the production process or products stored in the heated space might be affected by constituents of the diluted products of combustion. Where there is any doubt, the air heater manufacturer should be consulted.

4.2.3.1.2 The total installation, that is, the combination of the heater or heaters and the ventilation facilities in the room or rooms supplied with heated air, shall be designed and operated such that the concentration of carbon dioxide at positions where the air is normally, or is likely to be, inhaled by persons present shall not exceed 0.28 % (v/v; "volume concentration") or 2800 ppm.

NOTE 1 In the case of group H natural gas of the 2nd family, the specified maximum carbon dioxide concentration is approximately equivalent to one volume of products to 38 volumes of outside air being supplied to the spaces being heated, the volumes being referred to the same temperature. The concentration of carbon dioxide 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.

NOTE 2 Where air extraction is not achieved wholly by positive means, e.g. where it is extracted either by relief grilles or partly by fans, knowledge of the air change rate of the room concerned is required in order to assess the maximum heat input that avoids excessive carbon dioxide concentrations.

*NOTE 3 Any recirculation air intake should be located downstream of the burner, unless upstream recirculation is specifically authorized in the manufacturer's installation instructions. (See also **4.2.3.1.1**.)*

4.2.3.1.3 Additional ventilation shall be provided, if necessary, to ensure that the concentrations of other combustion gases (e.g. carbon monoxide and oxides of nitrogen) present within the room or rooms as a result of use of the direct gas-fired heater or heaters do not exceed the limits specified in HSE publication EH40 [20].

*NOTE Direct gas-fired air heaters that are designed to conform to BS EN 525 or BS 5990 and installed so as to conform to **4.2.3.1.2**, should produce environmental concentrations of combustion gases that are well within the limits specified in the HSE publication EH40 [20] (see Table A.1).*

4.2.3.1.4 In rooms where products of combustion are present from sources other than from the direct gas-fired air heater system, e.g. releases from small unflued appliances, the maximum values of combustion product concentrations shall include these local ambient levels (see Annex A).

NOTE This requirement can limit or preclude the use of direct gas-fired air heaters in some locations.

4.2.3.1.5 Air heaters intended for intermittent use, e.g. door curtain heaters, shall not be installed to operate continuously where combustion product concentrations higher than those specified in this standard would be produced and sustained in areas where inhalation is possible. A system that ensures that the heater operates intermittently, e.g. door position interlocks, shall be fitted to such installations.

4.2.3.2 High and low temperature fixed direct gas-fired air heaters

*COMMENTARY ON **4.2.3.2***

For low-temperature fixed air heaters, recirculation air should preferably enter the heater downstream of the burner.

*For high-temperature fixed air heaters the temperature of the air discharged into the heated space should not exceed 60 °C. Dilution of the heated air with fresh and/or room air might be necessary to achieve the temperature (see also **5.2**). Elevated duct or appliance exit temperatures might lead to poor temperature distribution in the heated space.*

Installations of low temperature fixed air heaters that are subject to adjustment of the recirculation air flow shall only use air heaters for which such air re-circulation is authorized in the manufacturer's instructions and shall include interlocks as required to prevent changes that would adversely affect combustion.

4.2.3.3 Transportable air heaters

4.2.3.3.1 Adequate ventilation air shall be provided to conform to the requirements specified in **4.2.3.1.2**, **4.2.3.1.3** and **4.2.3.1.4**.

4.2.3.3.2 Transportable heaters shall not be controlled by time switches or other remote controls.

4.2.3.4 Testing of combustion products

4.2.3.4.1 General

*COMMENTARY ON **4.2.3.4.1***

Air heaters conforming to BS 5990 or BS EN 525 should provide combustion product concentrations equal to or less than those shown in columns 3 and 4 of Table A.1. It should be noted that these limiting concentrations are attributable to the appliance and do not include any ambient concentrations. Internal air quality should be monitored in order to ascertain levels of carbon monoxide (CO) and carbon dioxide (CO_2) prior to, during, and on completion of maintenance and servicing routines, in accordance with BS 7967-5.

The instrumentation used to check the concentration of CO_2 shall comply with BS 8494 or BS EN 50543.

Heater installations shall conform to the requirements specified in **4.2.3.1**, **4.2.3.2** and **4.2.3.3** when tested in accordance with **4.2.3.4.2** and **4.2.3.4.3**.

4.2.3.4.2 Air heaters supplied with 100% fresh air

*COMMENTARY ON **4.2.3.4.2***

*For low-temperature fixed air heaters, where the temperature rise through the heater does not exceed 55 °C, the carbon dioxide concentration will not exceed 0.28%(v/v) or 2800 ppm as specified in **4.2.3.1.2**. For all other installations, sufficient ventilation is required to ensure that the specified carbon dioxide concentration is not exceeded (see **5.2** and **5.3**).*

*For installations where air extraction is not achieved wholly by positive means as described in **4.2.3.1.2**, conformity to specified maximum values can only be checked with certainty by actually testing the atmosphere. In addition, temperature rises below 55 °C might be necessary to prevent condensation.*

For air heaters installed so that all the inlet air over the burner is fresh air, either the carbon dioxide concentration in the heated air or the air temperature rise across the heater (where the temperature rise can be correlated to carbon dioxide levels) shall be measured under conditions of maximum heat input at the minimum and at all other available settings of the fresh air supply rate.

4.2.3.4.3 Air heaters with recirculation

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

4.3 Heat input rating for full space heating

If the air heater is, or air heaters are, specified to be the sole means of heating and intended to provide full heating, and not partial or localized heating, the rating shall be adequate to:

a) satisfy the steady state requirements of the room or rooms to be heated;

b) provide a margin above the steady state losses to ensure an appropriate heating up time;

c) provide for the heat losses from supply ducting that do not contribute heat to the room concerned (see **5.5.4**).

4.4 Resistance of the air delivery system

*COMMENTARY ON **4.4***

Most air heaters are designed to deliver the heated air directly into the heated space, via outlet grilles. The addition of a duct distribution system always reduces the volume of the delivered air from this free blowing state.

Some air heaters are capable of overcoming the resistance of the duct distribution system, possibly following adapting the heater. In these cases the manufacturer usually has performance curves for the fans to aid the design of the duct system.

It shall be ensured that the resistance of the installed air delivery system, including duct work, filters, heater grilles, etc. does not exceed the maximum resistance specified in the appliance manufacturer's instructions.

NOTE Consult the manufacturer for details of fan performance characteristics if in doubt.

4.5 Outside location

*COMMENTARY ON **4.5***

If there is any doubt about the suitability of the appliance for an outdoor location, the appliance manufacturer should be contacted prior to installation.

An air heater shall only be installed outdoors if this mode of installation is specifically allowed in the air heater manufacturer's installation instructions. The installation shall be carried out strictly in accordance with these instructions.

4.6 Materials and components

All materials and components used in the installation shall conform to the applicable British Standard or European Standard if such a standard exists. Where no British or European Standard exists, materials and components shall be of a suitable quality, and shall be designed, constructed and installed to fulfil their intended purpose and so as not to put the safety of persons at risk.

Materials containing asbestos shall not be used. High melting point solders incorporating cadmium shall not be used.

5 Installation

5.1 Installation and siting

5.1.1 General

5.1.1.1 Installation and siting shall be in accordance with the air heater manufacturer's installation instructions and associated data sheets.

5.1.1.2 Air heaters shall only be installed in locations where the environmental conditions are suitable.

NOTE 1 Corrosive or salty atmospheres can cause corrosion and/or failure of metal components, particularly heat exchangers, burners and controls.

*NOTE 2 In some locations, dusts from plastics forming/handling processes or gases from cleaning or curing are emitted into the heated space. Such products when passed through the combustion zone of space heating or other fuel burning appliances, or when passed over a heat exchanger, can produce both toxic and corrosive emissions. It is therefore recommended that in such cases precautions be taken to prevent the dusts or gases from entering the working atmosphere or from entering the combustion spaces, heat exchangers or flues of appliances. (See **4.2.2.1** and **4.2.3.1.1**.)*

NOTE 3 High wind speeds can adversely effect burner performance.

NOTE 4 Where there is any doubt, the installer should consult the heater manufacturer.

5.1.1.3 Any clearances around the air heater shall be at least the minimum specified in the manufacturer's installation instructions. Where the air heater is to be mounted on the floor, on a wall or otherwise suspended, the supporting surfaces shall be protected from overheating as detailed in the manufacturer's instructions. The clearances around the air heater shall ensure:

a) sufficient air circulation for any draught diverter to operate;

b) sufficient air for combustion and cooling;

c) that the complete system is fully accessible for maintenance and servicing.

5.1.1.4 Where required by the air heater manufacturer, a floor-mounted air heater shall be secured in accordance with the manufacturer's instructions. Wall-mounted air heaters shall be fixed in accordance with the manufacturer's instructions. Suspended air heaters shall be supported in accordance with the manufacturer's instructions and where necessary constrained to prevent a hazard to personnel. The installer shall ensure that the structure is suitable to support the weight of the heater and its equipment.

NOTE Where an air heater is installed above floor level, consideration should be given to the installation of walkways to assist maintenance and servicing.

5.1.1.5 Heaters sited such that they might suffer external mechanical damage, e.g. from overhead cranes, fork lift trucks, etc., shall be suitably protected.

5.1.1.6 Air heaters shall not be installed in those parts of spaces within buildings that have been classified as hazardous areas.

NOTE 1 It should be noted that correct hazardous area classification normally results in the identification of distinct zones within spaces, i.e. zone 0, 1 and 2 (see BS EN 60079-10-1). Consequently it might be possible to install heaters in safe areas, as defined, outside or above zones exposed to heavier-than-air vapours or gases.

*NOTE 2 See also **5.8.4**.*

5.1.1.7 An air heater for use with 3rd family, or heavier than air, gases shall not be installed in a room below ground level, e.g. in a basement or a cellar.

NOTE This does not preclude the installation of such air heaters into rooms which are basements with respect to one side of the building but open to ground level on the opposite side.

5.1.2 Siting where petroleum and other heavier-than-air flammable vapours are present

5.1.2.1 General

Air heaters supplying air to hazardous areas shall be located either outdoors (see **4.5**) or in a separate room or enclosure as specified in **5.1.2.2**.

Air heaters shall not be used to supply heated air to hazardous areas unless:

a) all incoming air to the heater is outside air;

b) the outlets from ducts into the space to be heated are sited at least 1.8 m above the floor level;

c) they have a full automatic and proven pre-purge and post-purge of the plenum chamber;

d) electrical apparatus, e.g. cables and switchgear, sited within 1.2 m of the floor level within the space to be heated is appropriately protected as defined in BS EN 60079-10-1.

In any application where flammable heavier-than-air vapours might be present but to be heated does not constitute a hazardous area, air heaters shall not be sited within the space unless:

- the base of the heater is at least 1.8 m above the floor level;
- cables and switchgear sited within 1.2 m of the floor level within the space to be heated are appropriately protected as defined in BS EN 60079-10-1.

NOTE The requirement is intended to apply to commercial garage workshop installations (see "IM 28, Appliances in commercial garages" [21]).

5.1.2.2 Rooms and enclosures housing heaters

Rooms and enclosured housing heaters that are either:

a) attached to or within hazardous areas and which supply air to those areas; or

b) supply air to areas other than hazardous areas where flammable heavier-than-air vapours might be present;

shall be separated from those areas by a construction of non-combustible materials of fire resistance of not less than 1 h when tested in accordance with BS 476-20, BS 476-21, BS 476-22, BS 476-23.

In the case of rooms or enclosures attached to or within hazardous areas there shall be no means of access from the room or an enclosure to the hazardous areas.

NOTE Access to such rooms or enclosures can only be achieved from areas other than hazardous areas.

Any doorway to the room or an enclosure giving access to areas other than hazardous areas where flammable heavier-than-air vapour might be present shall have a non-combustible sill, raised not less than 450 mm above floor level, and shall be fitted with a self-closing door having a fire resistance of not less than 1 h, when tested in accordance with BS 476-20, BS 476-21, BS 476-22, BS 476-23. When closed, the connecting door and its seal shall prevent the transmission of flammable vapours.

In the case of rooms or enclosures attached to or within hazardous areas there shall be no means of access from the room or an enclosure to the hazardous area.

5.2 Heater air supply

5.2.1 General

5.2.1.1 There shall be provision for a supply of air for combustion and, where relevant, for combustion products dilution and for ventilation of the enclosure or plant room. This requirement shall be met by conformity to **5.2.2** or **5.2.3** as appropriate.

NOTE The applicable requirements are dependent on the means of evacuating the products of combustion (appliance type). The following requirements are based on the appliance type system given in PD CEN/TR 1749:2009 which is generally utilized in British Standards or European Standards as a means of classifying gas-fired appliances. Descriptions of type B_1, type B_2, type C_1, and type C_3 appliances are given in Figure 1, Figure 2, Figure 3 and Figure 4.

5.2.1.2 High-level ventilation openings shall be located as high as is reasonably practicable. Low-level ventilation openings shall be located as low as is reasonably practicable and be within 1 m of the floor for a lighter-than-air gas and within 250 mm of the floor for a heavier-than-air gas.

NOTE It is preferable that high-level ventilation openings are located within 15% of the building height from the ceiling. For a heavier-than-air gas, it is preferable that low-level ventilation openings are located at floor level.

5.2.1.3 Where mechanical ventilation is used, automatic means for protection of the combustion air supply, such as interlocks, shall be provided for installations where equipment failures can lead to hazardous situations developing.

NOTE 1 For example, inlet air fan failure might cause a natural or forced draught appliance to suffer downdraught if the extract air fan continues to run, in which case the appliance, its associated fans and other equipment that is affected, needs to be shut down to avoid a hazardous situation developing.

NOTE 2 Consideration should also be given to any precautions that might need to be taken for plant fitted with extract hoods.

5.2.1.4 The following requirements shall apply in cases where mechanical ventilation is used.

a) The mechanical ventilation shall be by mechanical inlet and with either natural or mechanical extraction. Systems of ventilation employing mechanical extraction and natural air inlet shall not be used.

b) Where only a mechanical supply of air is used, the inlets shall be at low level. Natural outlet air vents shall be at high level.

c) Where there are any flued appliances in the enclosure, plant room or heated space and where outside air is supplied mechanically and there is mechanical extraction, the design extract rate shall be 5% to 10% less than the design inlet rate to make the room at a higher pressure than the outside air.

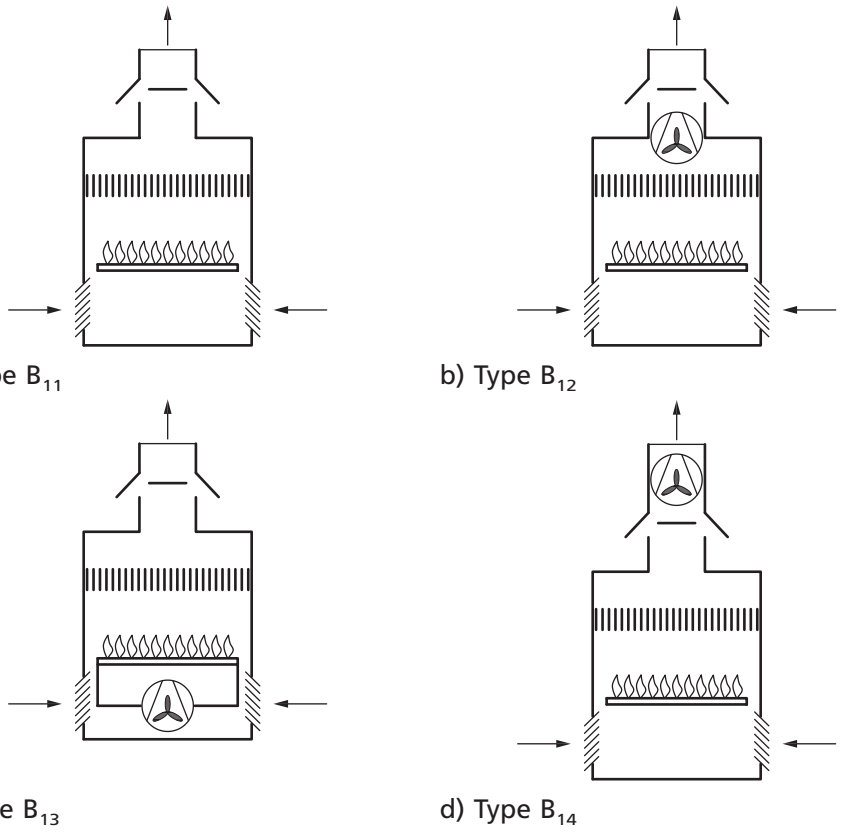
d) An automatic control shall be fitted to cause shut-down of the burner or burners in the event of failure of the air flow in either the mechanical inlet or the mechanical extract systems.

5.2.1.5 Where an air heater is installed in an enclosure or plant room, the heated air delivered to the heated space shall be ducted from the heater.

5.2.1.6 In the case of an indirect gas-fired air heater, the air to be delivered shall not be taken from the air within the enclosure or plant room.

5.2.1.7 In the case of a direct gas-fired air heater the air to be delivered shall be taken directly from the outside air. This air shall be ducted to the heater unless otherwise specified in the manufacturer's instructions.

Figure 1 **Type B_1 heaters**



a) Type B_{11} b) Type B_{12}

c) Type B_{13} d) Type B_{14}

NOTE 1 A type B heater is a heater intended to be connected to a flue that evacuates the products of combustion to the outside of the room containing the heater. The combustion air is drawn directly from the room. A type B_1 heater is a type B heater incorporating a draught diverter.

NOTE 2 A type B_{11} heater is a natural draught type B_1 heater.

NOTE 3 A type B_{12} heater is a type B_1 heater designed for a natural draught flue incorporating a fan downstream of the combustion chamber or heat exchanger and upstream of the draught diverter.

NOTE 4 A type B_{13} heater is a type B_1 heater designed for a natural draught flue incorporating a fan upstream of the combustion chamber or heat exchanger.

NOTE 5 A type B_{14} heater is a type B_1 heater having an integral fan downstream of both the combustion chamber or heat exchanger and the draught diverter.

5.2.1.8 Any return air shall be ducted directly to the heater so that it does not mix with the air in the enclosure or plant room.

*NOTE The intention of the requirement in **5.2.1.5, 5.2.1.6, 5.2.1.7** and **5.2.1.8** is to ensure that the air pressure within the enclosure or plant room remains at, or near, atmospheric pressure.*

5.2.2 Indirect gas-fired air heaters

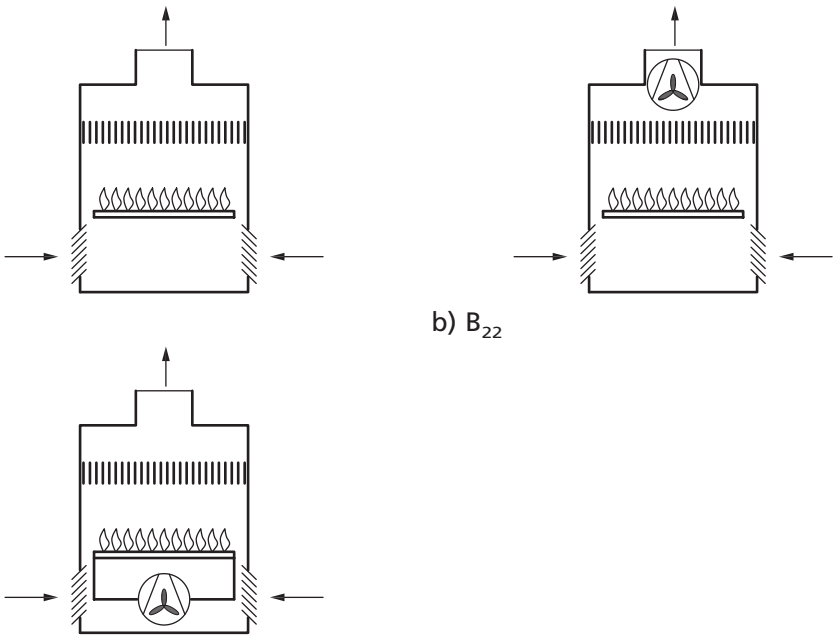
5.2.2.1 Room-sealed air heaters of type C_1 and type C_3

*COMMENTARY ON **5.2.2.1***

*The requirements in **5.2.2.1.1** do not apply to open-flued air heaters of type B, installed in room-sealed compartments* [2)]

[2)] Room-sealed compartments are also commonly known as balanced compartments.

Figure 2 **Type B_2 heaters**



NOTE 1 A type B_2 heater is a type B heater without a draught diverter.

NOTE 2 A type B_{21} heater is a natural draught type B_2 heater.

NOTE 3 A type B_{22} heater is a type B_2 heater incorporating a fan downstream of the combustion chamber or heat exchanger.

NOTE 4 A type B_{23} heater is a type B_2 heater incorporating a fan upstream of the combustion chamber or heat exchanger.

In the case of these room-sealed heaters, combustion air is ducted to the appliance and the combustion products ducted to the outside air. No additional provisions for the supply of combustion air or for combustion products dilution are necessary.

In the case of installation in heated spaces no additional provisions for the supply of air are necessary.

5.2.2.1.1 Installation in a plant room or enclosure

*COMMENTARY ON **5.2.2.1.1***

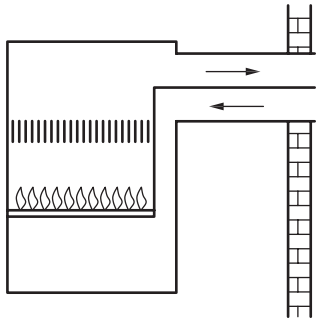
*The purpose of the air vents is to supply air for cooling. See **5.2.1.2**.*

The ventilation provided should be adequate to ensure that the enclosure or plant room temperature does not exceed 32 °C.

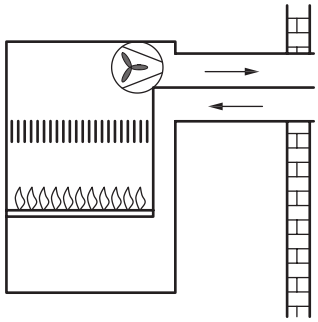
*See also **5.2.1.5**.*

Unless the appliance manufacturer's installation instructions state otherwise, air vents shall be provided in a plant room or enclosure containing a type C_1 or type C_3 air heater and shall be sized in accordance with Table 4, at both high and low levels. Air vents shall be permanently open.

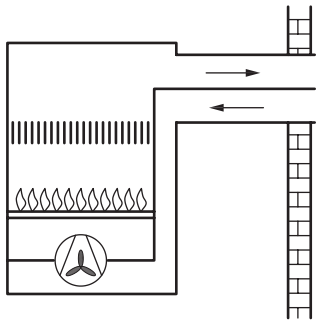
Figure 3 **Type C_1 heaters**



a) Type C_{11}



b) Type C_{12}



c) Type C_{13}

NOTE 1 A type C heater is a heater in which the combustion circuit (air supply, combustion chamber, heat exchanger and evacuation of the products of combustion) is sealed with respect to the room in which the heater is installed. A type C_1 heater is a type C heater that is designed for connection via its ducts to a horizontal terminal, which at the same time admits fresh air to the burner and discharges the products of combustion to the outside through orifices that are either concentric or close enough to come under similar wind conditions.

NOTE 2 A type C_{11} heater is a natural draught type C_1 heater.

NOTE 3 A type C_{12} heater is a type C_1 heater incorporating a fan downstream of the combustion chamber or heat exchanger.

NOTE 4 A type C_{13} heater is a type C_1 heater incorporating a fan upstream of the combustion chamber or heat exchanger.

5.2.2.2 Type B appliances

5.2.2.2.1 Installation in heated spaces

5.2.2.2.1.1 General

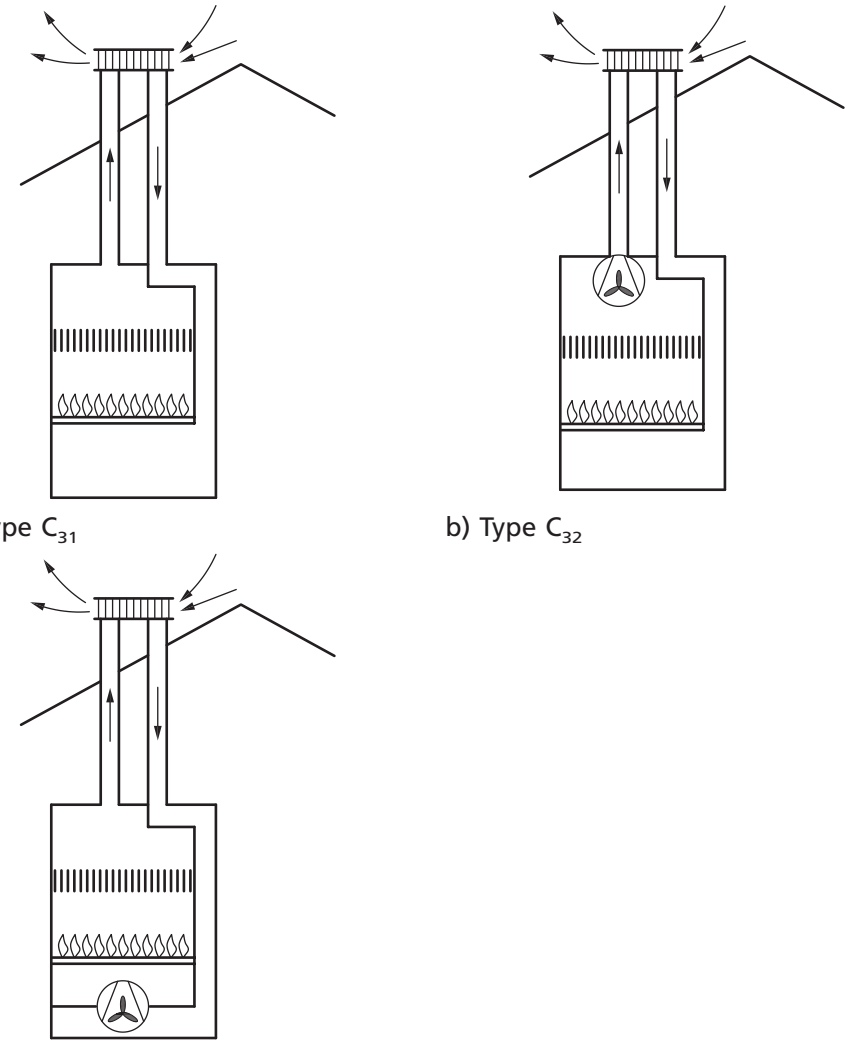
In buildings having a design air change rate of less than 0.5 /h, the requirements of **5.2.2.2.1.2** or **5.2.2.2.1.3** shall apply, depending on whether the provision of ventilation air is natural or mechanical.

NOTE In buildings with a design air change rate of 0.5 /h or greater, additional natural or mechanical ventilation is not necessary.

5.2.2.2.1.2 Natural ventilation

Ventilation openings with a free area of at least 2 cm^2 per kW of rated heat input shall be provided at low level (i.e. below the level of the heater flue connection) for both type B_1 air heaters (with draught diverters) and type B_2 air heaters (without draught diverters).

Figure 4 **Type C_3 heaters**



a) Type C_{31}

b) Type C_{32}

c) Type C_{33}

NOTE 1 A type C_3 heater is a type C heater that is designed for connection via its ducts to a vertical terminal, which at the same time admits fresh air to the burner and discharges the products of combustion to the outside through orifices that are either concentric or close enough to come under similar wind conditions.

NOTE 2 A type C_{31} heater is a natural draught type C_3 heater.

NOTE 3 A type C_{32} heater is a type C_3 heater incorporating a fan downstream of the combustion chamber or heat exchanger.

NOTE 4 A type C_{33} heater is a type C_3 heater incorporating a fan upstream of the combustion chamber or heat exchanger.

Table 4 **Minimum air vent free area for room-sealed type C_1 or type C_3 appliances installed in a plant room or enclosure**

Vent position	Means of ventilation	
	To room or internal space	Direct to outside air
	cm^2 per kW (net) of maximum heat input	cm^2 per kW (net) of maximum heat input
High level	10	5
Low level	10	5

5.2.2.2.1.3 Mechanical ventilation

Sufficient ventilation air shall be provided, in accordance with the requirements of **5.2.1.5**, so as to ensure that the building air change rate is at least 0.5 /h.

5.2.2.2.2 Installation in plant rooms or enclosures

5.2.2.2.2.1 General

The requirements of either **5.2.2.2.2.2** or **5.2.2.2.2.3** shall apply, depending on whether the provision of ventilation air is natural or mechanical.

NOTE 1 The ventilation provided should be adequate to ensure that the enclosure or plant room temperature does not exceed 32 °C.

*NOTE 2 See also **5.2.1.5**.*

5.2.2.2.2.2. Natural ventilation

Unless the appliance manufacturer's installation instructions state otherwise, air vents shall be provided in a plant room or enclosure containing a type B_1 appliance (with draught diverter) or a type B_2 appliance (without draught diverter), that communicate directly with the outside air and have a total minimum free vent area as follows.

a) For plant rooms:

   1) low level (inlet): 4 cm^2 per kilowatt of total rated net heat input;

   2) high level (outlet): 2.0 cm^2 per kilowatt of total rated net heat input.

b) For enclosures:

   1) low level (inlet): 10 cm^2 per kilowatt of total rated net heat input;

   2) high level (output): 5 cm^2 per kilowatt of total rated net heat input.

*NOTE See **5.2.1.2**.*

5.2.2.2.2.3 Mechanical ventilation

Unless the appliance manufacturer's installation instructions state otherwise, the minimum flow rate of ventilation air shall be as follows.

a) In the case of a type B_1 appliance (with draught diverter), 4.3 m^3/h per kilowatt of total rated heat input.

b) In the case of a type B_2 appliance (without draught diverter), 4.14 m^3/h per kilowatt of total rated heat input.

The mechanical ventilation shall be provided in accordance with **5.2.1.4**. If high level natural ventilation is provided as an alternative to mechanical extraction, the total minimum free area of the vent or vents shall conform to the corresponding requirement in **5.2.2.2.2.2**.

5.2.3 Direct gas-fired air heaters

5.2.3.1 Installation in heated spaces

The provision of air for combustion and dilution of products of combustion shall be met by conformity to building ventilation requirements specified in **5.3.2**.

5.2.3.2 Installation in plant rooms or enclosures

5.2.3.2.1 General

*COMMENTARY ON **5.2.3.2.1***

Where the air to be delivered is ducted to the heater, the ventilation provided is only for the purposes of cooling. The ventilation provided should be adequate to ensure that the enclosure or plant room temperature does not exceed 32 °C.

If the air to be delivered is not ducted to the heater, ventilation for the purposes of supplying air for combustion, combustion products dilution and cooling is necessary.

The requirements of **5.2.3.2.2** or **5.2.3.2.3** shall apply, depending on:

a) whether the provision of ventilation air is natural or mechanical; and

b) whether or not, in accordance with the requirements of **5.2.1.5**, the air to be delivered is ducted to the heater.

5.2.3.2.2 Natural ventilation

5.2.3.2.2.1 If, in accordance with the manufacturer's instructions, the air to be delivered is ducted to the heater, ventilation shall be provided as follows.

Unless the appliance manufacturer's installation instructions state otherwise, air vents shall be provided in the plant room or enclosure, that communicate directly with the outside air and have a total minimum free vent area as follows.

a) Low level:

   1) for heaters of total rated heat input not exceeding 70 kW: 5.0 cm^2 per kilowatt of rated heat input;

   2) for heaters of total rated heat input exceeding 70 kW: 350 cm^2 plus 2.5 cm^2 per kilowatt in excess of 70 kW rated heat input.

b) High level:

   1) for heaters of total rated heat input not exceeding 70 kW: 5.0 cm^2 per kilowatt of rated heat input;

   2) for heaters of total rated heat input exceeding 70 kW: 350 cm^2 plus 2.5 cm^2 per kilowatt in excess of 70 kW rated heat input.

*NOTE Both high and low level vents should communicate with the outside air at the same wall. The vertical distance between the high and low vents should be as great as is possible to encourage a convective air flow. See **5.2.1.2**.*

5.2.3.2.2.2 If, in accordance with the manufacturer's instructions, the air to be delivered is not ducted to the heater, air vents shall be provided in the plant room or enclosure, that communicate directly with the outside air and have a total minimum free vent area as specified in the manufacturer's instructions.

5.2.3.2.3 Mechanical ventilation

5.2.3.2.3.1 Air ducted to the heater

If, in accordance with the manufacturer's instructions, the air to be delivered is ducted to the heater, ventilation shall be provided as follows.

Unless the appliance manufacturer's installation instructions state otherwise, the minimum flow rate of ventilation air shall be 2.4 m^3/h per kilowatt of rated heat input.

The mechanical ventilation shall be provided in accordance with **5.2.1.4.** If high level natural ventilation is provided as an alternative to mechanical extraction, the total minimum free area of the vent or vents shall conform to the corresponding requirement in **5.2.3.2.2.1**.

5.2.3.2.3.2 Air not ducted to the heater

If in accordance with the manufacturer's instructions the air to be delivered is not ducted to the heater, the minimum flow rate of ventilation air shall be as specified in the heater manufacturer's installation instructions.

The mechanical ventilation shall be provided in accordance with **5.2.1.4**. If high level natural ventilation is provided as an alternative to mechanical extraction, the total minimum free area of the vent or vents shall be at least that specified in the manufacturer's instructions.

5.3 Building ventilation

5.3.1 General

5.3.1.1 Ventilation air shall be taken from an outside point where it is not likely to be contaminated, for example with smells, road vehicle exhausts, dry cleaners' exhausts, etc.

NOTE 1 Condensation can occur on cold steel components, steel structures, windows, and in poorly ventilated roof spaces or between poorly sealed structural members.

NOTE 2 Additional fan capacity might be needed to control condensation on poorly insulated structural or cold surfaces. Brief information is given in Digest 180, "Condensation in roofs" [22] and Digest 297, "Surface condensation and mould growth in traditionally-built dwellings" [23].

5.3.1.2 The assessment of ventilation and maximum heat input rates shall take account of all equipment, including process equipment and vehicles that release heat and/or products of combustion into the heated space.

NOTE Internal air quality should be monitored in order to ascertain levels of carbon monoxide (CO) and carbon dioxide (CO_2) prior to, during, and on completion of maintenance and servicing routines, in accordance with BS 7967-5.

5.3.1.3 The minimum quantity of outside air required for ventilation shall be at least that required for personnel within the building. Allowance shall be made for carbon dioxide emissions from persons occupying the heated space.

NOTE 1 Consideration should be given to providing sufficient quantities of air for an odourless atmosphere. Recommended minimum fresh air supply rates are given in CIBSE's "Guide B" [24]. Attention is drawn to "HSG 202, General ventilation in the workplace" [25].

NOTE 2 Where air heaters are located in the heated space the air supply requirement is not necessarily the sum of the individual requirements for combustion, ventilation and dilution air, and fresh air, but the greater individual requirement.

5.3.1.4 Where there are any flued appliances in the room and where outside air is supplied mechanically and there is mechanical extraction, the design extract rate shall be 5% to 10% less than the design inlet rate so that the room will be at a higher pressure than the outside air.

5.3.1.5 Air filters shall be fitted when considered necessary (see BS 5720).

5.3.2 Direct gas-fired air heaters

5.3.2.1 For direct gas-fired air heaters, ventilation of the heated space shall be adequate to limit the concentration of carbon dioxide to not more than 0.28% (V/V) 2800 ppm at positions where the heated air will, or is likely to, be inhaled, i.e. as given in **5.3.1.2**. This ventilation shall be achieved either by the air heater or by other mechanical or natural ventilation methods (see BS 5925).

5.3.2.2 Where fresh air inlet and extract fans are fitted to enable the requirements of **5.3.1.2**, **5.3.1.3** and **5.3.2.1**, to be met, interlocks shall be provided so that direct gas-fired air heaters do not operate unless sufficient fans are in operation to provide adequate ventilation to keep the carbon dioxide concentration below the specified maximum of 0.28% (V/V)2800 ppm.

5.3.2.3 The free vent area of air vents shall not be adjustable unless otherwise specified in the manufacturer's installation instructions. Where carbon dioxide control systems are applied to direct-fired air heating systems, they shall be designed to be inherently fail safe. Damper motors shall be of a fail safe design, e.g. spring operated on motor failure to give zero recirculation and maximum flow of outside air.

NOTE 1 Carbon dioxide control systems should be applied with great care. Users should be advised of the importance of ensuring that all inlet and exhaust air systems are operating correctly and that the carbon dioxide controller is regularly calibrated.

NOTE 2 Where carbon dioxide control is to be used, it is strongly recommended that the air heater manufacturer be consulted.

5.4 Air vents

5.4.1 All air vents communicating with outside air shall be sited such that there is an adequate separation between the air vent and any part of an appliance flue terminal in order to minimize the risk of re-entry of the products of combustion.

NOTE BS 5440-2 and "The Building Regulations Approved Document J" [26] give information on minimum separation distances.

5.4.2 Any air vent communicating directly with outside air should not be located in a position where it is likely to be easily blocked, e.g. by leaves or snow or other debris, become flooded, or where contaminated air might be present at any time.

NOTE In the case of appliances designed for outdoor installation and conforming to the requirements of BS EN 525 or BS EN 1020, the lowest edge of any air inlets is required to be 500 mm above the base of the appliance or above floor level when installed in accordance with the manufacturer's instructions.

5.4.3 If an air vent for a plant room or enclosure does not communicate directly with outside air, it shall not communicate with a hazardous area.

5.5 Ducting

5.5.1 All ducting, including air filters, jointing, insulation and lining, shall be constructed entirely of materials of adequate strength and shall remain dimensionally stable at the maximum internal and external temperatures to which they will be exposed during commissioning and normal operation. In the selection of materials, account shall be taken of the working environment and the resulting air temperatures when the overheat limit thermostat is being commissioned. Combustible materials located near ducting shall not be exposed to temperatures in excess of 65 °C.

5.5.2 Precautions shall be taken to restrict the spread of smoke and fire, e.g. by fire dampers and fire stopping.

NOTE Attention is drawn to the relevant Building Regulations [6], [7], [8], BS 5720, BS 8313 and BS 5588.

5.5.3 Joints and seams of ducting and fittings shall be securely fastened. Leakage shall be minimized and in certain cases complete sealing will be necessary.

NOTE Further guidance is given in "DW/144, Specification for sheet metal duct work" [26].

5.5.4 All delivery and return air ducts in spaces where heating is not required, e.g. roof voids, shall be thermally insulated with a material having a thermal resistance [3)] of not less than 0.62 m^2 K/W.

5.5.5 Where damp conditions are likely to be encountered, e.g. in roof top installations and preformed concrete channels, the ducting shall be protected by waterproof membranes and vapour barriers. Where a soft insulating material is used, care shall be taken not to compress or otherwise damage it when applying the waterproof membrane or vapour barrier.

NOTE Such damage might impair the insulating properties of the materials.

5.5.6 All ducting shall be securely supported in such a way that it is not under undue strain and does not sag. No undue strain shall be placed on any of the joints or on the appliance.

5.5.7 Where a flexible coupling is used to connect the heater to the ducting, it shall be airtight and manufactured from non-combustible material.

5.5.8 Openings in walls, partitions, etc., through which ducting passes, shall be large enough to give a clearance around the duct to allow movement due to the normal thermal expansion (see also **5.5.2**).

5.5.9 Duct supports shall also allow movement due to normal thermal expansion but this movement shall not damage insulation or vapour barriers fitted.

5.5.10 Where ducting passes through a fire barrier, the materials used to support the ducting shall be such as to maintain the integrity of the fire barriers.

NOTE Where the barrier is a 1 h fire resisting wall the ducting, fire stopping and associated fire damper should not become displaced by thermal movement or collapse for at least 1 h under fire conditions.

5.6 Return air ducting

In installations employing ducted recirculation, the ducting shall conform to **5.5** together with the following.

a) There shall be an unobstructed return air path to the heater.

b) Dampers shall be securely fixed in their correct positions except that recirculating duct dampers may be closed during periods of hot weather to increase the ventilation rate.

c) For indirect-fired heaters, the return air grilles shall be connected by ducting directly to the return air inlet on the heater.

d) For direct-fired heaters, any return air supply shall not interfere with the ignition and correct combustion performance of the burner or burners.

e) Where automatic or manual dampers are provided for operational adjustment in recirculation ducts of direct-fired air heater systems, they shall be proved in the correct open position before and during the start of the burner ignition sequence and during the operation of the burner unless the recirculation air is introduced downstream of the burner.

*NOTE Recirculation should preferably be downstream of the burner (see **4.2.3.1.1** and **4.2.3.1.2**).*

[3)] Also known as thermal insurance.

5.7 Gas supplies and pipework

5.7.1 2nd family gases

5.7.1.1 It shall be ensured that the gas pressure in a new or existing service pipe is controlled so as to supply gas at a pressure suitable for the air heater (see Table 3).

5.7.1.2 The installer shall confirm with the gas supplier or gas transporter that a new or existing service pipe supplying the air heater is of sufficient size for the appliance and the required gas rate of the whole installation.

5.7.1.3 When a meter is fitted by a gas supplier or gas transporter, the installer shall confirm that the meter is of sufficient capacity for the required gas rate of the whole installation.

5.7.1.4 Installation pipework shall be sized and installed in accordance with the Institution of Gas Engineers and Managers publication IGE/UP/2, "*Gas installation pipework, boosters and compressors on industrial and commercial premises*" [27].

5.7.1.5 The installation of any gas booster shall be in accordance with the Institution of Gas Engineers and Managers publication IGE/UP/2, "*Gas installation pipework, boosters and compressors on industrial and commercial premises*" [27].

5.7.1.6 Unless this is already an integral part of the appliance, the gas supply to individual appliances shall be fitted with a suitable manual isolation valve.

5.7.1.7 Transportable heaters shall be connected to the gas installation pipework using as little flexible pipework as is practicable. In no case shall the flexible pipework at either end of the rigid pipework exceed 1 m in length. The flexible pipe(s) shall be made of armoured stainless steel or bronze capable of withstanding 3.5 bar or 1.5 times the working pressure, whichever is greater (see BS EN ISO 10380 and BS 6501-1). A 90° action manual valve shall be fitted such that all flexible pipework can be isolated.

5.7.2 3rd family gases (LPG)

5.7.2.1 Where an air heater is supplied with third family gas it shall be ensured that the gas pressure is controlled so as to supply gas at a pressure suitable for the air heater (see Table 3).

NOTE 1 LPG gas containers having a total capacity exceeding 100 kg should not be installed or stored within the premises, including any air heater enclosure or plant room, unless a fully documented risk analysis has been carried out.

NOTE 2 UKLPG's Code of practice No. 24 Part 5, "The storage and use of LPG on construction sites" [28] might also provide guidance in some air heater applications (e.g. in the case of transportable air heaters).

NOTE 3 UKLPG's Code of practice No. 24.6 Part 6, "The use of propane in cylinders at commercial and industrial premises" [29] gives guidance on safe practice.

5.7.2.2 The 3rd family gas pipework system shall be in accordance with the UKLPG's Code of practice No. 22, "*LPG piping, system design and installation*" [30].

5.8 Electrical controls and connections

5.8.1 All wiring external to the heater shall be carried out and checked in accordance with BS 7671. For heaters installed in areas as described in **5.1.2**, the electrical supplies and controls shall be installed as above and in accordance with **5.1.2.2** d) or **5.1.2.3** b).

NOTE Attention is drawn to The Electricity at Work Regulations 1989 [15].

5.8.2 Components shall be checked to ensure that they are suitable for the voltage range and frequency available.

5.8.3 The electrical supply to the heater shall incorporate suitable means of excess current protection and local isolation.

NOTE This means of isolation should allow removal of the appliance without exposing live parts.

5.8.4 All electrical enclosures, components and cabling shall be suitable for the environment, in particular with regard to any hazardous area classification (see DSEAR [31] and their supporting ACOPs, HS(L)134 [32], HS(L)135 [33], HS(L)136 [34], HS(L)137 [35] and HS(L)138 [36], and INDG 370 [37]), temperature and dust effects. In addition:

a) all electrical components, cables, etc. shall be suitable for the electrical supply available;

b) all electrical components with voltage range selectors shall be adjusted to the value of voltage available at the supply;

c) all electrical components shall be connected in accordance with the manufacturer's instructions;

d) any electrical component requiring removal for periodic serving shall be provided with ready means of disconnection, such as plugs and sockets, and shall be sited so as to be readily accessible;

e) all earth and electrical bonding conductors shall be of copper and of sufficient cross-sectional area and the insulation provided on any earth or bonding conductors shall have the colour combination yellow and green; and

f) all overload earth fault and excess current protection shall be appropriately rated.

5.9 Other controls

5.9.1 A means of regulating the heater output to meet design conditions shall be provided.

NOTE GPG 303, "The designer's guide to energy-efficient buildings for industry" [38] provides guidance on the application of warm air heating systems.

5.9.2 Ancillary controls shall be connected to the heater in accordance with the heater manufacturer's wiring and installation instructions. These ancillary controls shall include a time control enabling the operating period(s) of the heater to be controlled.

NOTE Space heater controls are addressed in "Approved Document L2 of the Building Regulations" [10].

5.10 Flues for indirect gas-fired air heaters

5.10.1 Appliances types

*COMMENTARY ON **5.10.1***

The applicable requirements are dependent on the means of evacuating the products of combustion (appliance type). The following requirements are based on the appliance type system given in PD CEN/TR 1749:2009 which is generally utilized in British Standards or European Standards as a means of classifying gas-fired appliances.

5.10.1.1 Condensation

5.10.1.1.1 General

The flue system shall be so designed and constructed as to provide satisfactory control of water condensation.

5.10.1.1.2 Non-condensing heaters

If condensation within the flue is conceivable at times other than during first start up of the burner an insulated flue, e.g. a double-walled flue, shall be used and/or the requirements specified in **5.10.1.1.3** shall apply.

5.10.1.1.3 Condensing heaters

The flue lining components shall be impervious to condensates and shall be suitably resistant to corrosion. Appropriate provisions shall be made for draining and disposal of the condensate (see **4.2.2.2**). Any condensate drain pipe or pipes from the flue to the disposal point shall be suitably resistant to corrosion (see **4.2.2.2**c)), and preferably not less than 22 mm internal diameter.

5.10.1.2 Flue dampers

Flue dampers shall not be installed unless this is specifically allowed in the manufacturer's installation instructions. If flue dampers are permitted, their installation, together with the necessary safety devices and interlocks, shall be carried out in accordance with the manufacturer's installation instructions.

5.10.2 Room sealed air heaters of type C_1 and type C_3

5.10.2.1 The flue system shall be assembled and installed in accordance with the manufacturer's installation instructions and utilizing the components supplied with the heater.

5.10.2.2 The terminal shall be so positioned externally as to allow the dispersal of products of combustion and the intake of air. In particular, there shall be an adequate separation between the flue terminal and other openings in the building in order to minimize the risk of re-entry of the products of combustion.

NOTE BS 5440-1 and The Building Regulations Approved Document J [9] give information on flue locations and minimum separation distances.

5.10.2.3 The terminal shall be fitted with a guard if it is less than 2 m above ground level to prevent blockage or injury to persons.

5.10.3 Type B air heaters

5.10.3.1 General

5.10.3.1.1 If it is intended to install a type B air heater on an existing flue (or chimney) for which a notice plate is displayed, the installer shall ensure that the air heater is suitable for use on that chimney or flue.

NOTE 1 The notice plate might include a designation which identifies various performance characteristics. The installer should find the appropriate information in the appliance manufacturer's instructions in order to determine whether the air heater is suitable for use on that flue, but in case of doubt the appliance manufacturer should be contacted before installation. This situation arises from the ongoing preparation of European Standards for a wide range of chimneys, which will eventually replace any existing British Standards.

NOTE 2 The need to post information on the correct application and use of chimneys in buildings is a matter addressed by the Building Regulations.

NOTE 3 Useful information on these matters is given in the "Building Regulations Approved Document J" [9] and "Approved Document J: Guidance and Supplementary Information on the UK Implementation of European Standards for Chimneys and Flues" [26].

5.10.3.1.2 The flue system shall be in accordance with the air heater manufacturer's installation instructions.

NOTE 1 The manufacturer's installation instructions might also refer to standards and other publications giving guidance on flue systems e.g. BS 5440-1 and BS 5854.

NOTE 2 Attention is drawn to "Safety in the installation and use of gas systems and appliances (L56)" [19], which gives guidance on conformity to "The Gas Safety (Installation and Use) Regulations 1998" [2]. Appendix 4 of this former publication gives a more comprehensive list of standards and other useful publications to which reference could be made.

5.10.3.1.3 Unless otherwise specified in the appliance manufacturer's installation instructions, flue components and their materials of construction shall be in accordance with the appropriate British or European standards.

NOTE It should be noted that a range of European chimney standards which will replace existing British standards are in the course of preparation. "Approved Document J" [9] gives details of the European Standards in the course of preparation.

5.10.3.2 Flue termination

5.10.3.2.1 For air heaters with a rated heat input not exceeding 70 kW net (77 kW gross), the flue termination shall be in accordance with BS 5440-1.

5.10.3.2.2 The terminal shall be so positioned externally as to allow the dispersal of products of combustion and the intake of air.

NOTE BS 5440-1, "The Building Regulations Approved Document J" [9] and the 1956 Clean Air Act Memorandum on chimney heights [38] give information on flue locations.

5.10.3.2.3 Where a type B_2 air heater has a wall termination, there shall be an adequate separation between the flue terminal and other openings in the building in order to minimize the risk of re-entry of the products of combustion.

NOTE BS 5440-1and "The Building Regulations Approved Document J" [9] give information on minimum separation distances but see also the 1956 Clean Air Act Memorandum on chimney heights [38].

5.10.3.2.4 The wall terminal for a type B_2 air heater shall be fitted with a guard if it is less than 2 m above ground level to prevent blockage or injury to persons.

5.10.3.3 Fans in flues

Air heaters shall not be fitted with a fan in the flue system serving the appliance unless this is specifically allowed by the appliance manufacturer's installation instructions. Such a fan shall only be installed as specified in these instructions.

5.10.3.4 Common flues

Air heaters shall not be installed on a common flue system unless this is specifically allowed by the manufacturer's installation instructions. Where such installation is permitted it shall be carried out in accordance with the manufacturer's instructions.

6 Post-installation

6.1 Inspection, commissioning and servicing

Before it is commissioned, the installation shall be thoroughly checked to ensure that the work has been carried out in accordance with the system designer's requirements.

It shall be ensured that:

a) the provision of ventilation and combustion air conforms to **5.2**;

b) any flue is correctly constructed;

c) the arrangement of fresh air, heater supply air and return air ducting is adequate (see **5.3** and **5.5**);

d) the general condition of the air heater and the installation is adequate;

e) the gas fittings and other works for the supply of gas are adequate;

f) the electrical fittings and other works for the supply of electricity conform to **5.8**.

NOTE To conform to the requirement specified in a), it might be necessary to consult the installation designer to verify his calculations.

6.2 Commissioning

6.2.1 Commissioning shall be carried out in accordance with the heater manufacturer's instructions in a series of logical steps that check the operation of all controls, motors and valves prior to the admission of gas to the burner.

NOTE A typical list of checks to be carried out prior to commissioning the burner is given in Annex B.

6.2.2 A complete and faultless dry run shall be achieved prior to allowing gas to the burner for the live run commissioning procedure (see **6.2.3**). Such a dry run shall include checking the correct operation, setting and gas soundness of manual valves, safety shut-off valves, gas pressure switches, non-return valves and governors and any other controls and safety devices.

6.2.3 The burner shall be commissioned in a series of logical steps that check that the controls are operating correctly and that purge and combustion air supplies are adequate and that the flue is operating correctly.

NOTE A typical list of live run checks to be carried out is given in Annex C.

6.2.4 After the commissioning is complete, a written record shall be made and left with the customer giving:

a) control and limit thermostat settings;

b) air and gas pressure switch settings;

c) regulator outlet and burner manifold pressures at high and low fire;

d) oxygen and/or carbon dioxide concentration in the flue gases at high and low fire, and flue gas temperatures where taken for indirect-fired appliances measured upstream of any downdraught diverter or stabilizer in accordance with the manufacturer's commissioning instructions;

e) carbon dioxide levels for direct-fired appliances measured as specified in **4.2.3**.

6.3 User instructions

6.3.1 The commissioning engineer shall ensure that brief user instructions for the safe operation and lighting of the heater are clearly provided in writing on or adjacent to the heater and any remote control panels. Alternatively, the commissioning engineer shall hand these written instructions to the end user.

6.3.2 The commissioning engineer shall ensure that wiring diagrams for the heater and its ancillary controls are given to the user or are attached to the heater.

6.3.3 The commissioning engineer shall ensure that the user or his representative is instructed in the safe operation, lighting-up and shutting-down procedures for the heater.

6.3.4 The commissioning engineer shall ensure that the user or his representative is advised of the method and frequency of servicing, the life of replaceable items, such as air filters and fan belts, and allied servicing aspects and that flexible gas pipes need to be visually inspected and checked for gas tightness, e.g. by using a proprietary leak detection fluid.

6.3.5 The instructions shall advise users of transportable direct-fired air heaters that the operation of these heaters requires attendance, i.e. that they are in the charge of a person who has been trained to operate the units correctly and who is also sufficiently near or accessible to remedy any unsafe condition before a hazard can or is likely to arise.

6.3.6 The commissioning engineer shall make the end user aware of any need to maintain the safe discharge of condensate (where appropriate) with particular reference to the discharge drainage facilities.

6.4 Maintenance

6.4.1 The installer of a gas-fired heater shall ensure that the user is aware of the importance of regular servicing and shall recommend in writing that arrangements are made for servicing to be carried out at least once per year.

6.4.2 Annual servicing shall include a check of the combustion performance to ensure that the air to gas ratio for indirect-fired air heaters is set according to the manufacturer's instructions and that direct-fired heaters conform to the requirements specified in **4.2.3**.

NOTE Air heaters designed for and fitted as outdoor installations require the provision of protective covers over valves and electrical panels in order that servicing can be carried out safely during inclement weather. The manufacturer's instructions can be consulted for advice on this matter.

6.4.3 The installer shall supply in writing a list of recommended spare parts to be kept by the user in the interests of maintaining continuity of heat service. The installer shall draw the user's attention to the servicing instructions provided by the manufacturer and, in particular, shall stress that any servicing procedure shall incorporate determination of:

a) the effectiveness of the flue;

b) the effectiveness of the combustion air supply;

c) the heat input and operating pressure;

d) the safe operation of the appliance.

Attention shall also be drawn to the necessity for notifying the person responsible for the premises in which the appliance is situated of any defect found during the servicing procedure.

Annex A (informative) Occupational exposure limit

The exposure limits given in Table A.1 are taken from HSE publication EH40, "List of approved workplace exposure limits" [20].

NOTE 1 The Health and Safety Executive Guidance Notes are revised from time to time.

NOTE 2 The limiting concentrations given in BS 5990:2006 and BS EN 525:2009 have been included in Table A.1 for information. It should be noted that these limiting concentrations are attributable to the appliance and do not include any ambient concentrations.

Table A.1 **Occupational exposure limits**

Gas or Vapour	EH 40 limits		Limiting concentration permitted by BS 5990:2006		Limiting concentration permitted by BS EN 525:2009	
	ppm	mg·m^3	ppm	% V/V	ppm	% V/V
Carbon dioxide (CO_2)	5 000	9 150	2 800	0.28	2 500	0.25
Carbon monoxide (CO)	30	35	10	0.001	10	0.001
NitricOxide (NO)	25	31	5	0.000 5	5	0.000 5
Nitrogen dioxide (NO_2)	3	5.7	1	0.000 1	1	0.000 1

Annex B (informative) Checks to be carried out prior to commissioning

The following is a typical list of checks which should be carried out prior to commissioning the burner.

a) Check that the manual gas valves are in the closed position and that suitable warning notices are attached.

b) Check that all electrical supplies are isolated and that suitable warning notices are attached.

c) Check and adjust fan belt tensions.

d) Check that the filter assemblies are inserted and correctly located (where fitted).

e) Check electrical earth continuity between the appliance, gas pipework and the mains electrical supply.

f) Check that electrical components are of the correct voltage range, particularly low voltage ancillary controls.

g) Check that the direction of rotation of the fan or fans is correct and that the fan or fans are moving freely.

h) Check fan motor currents and adjust starter overload settings.

i) Check and adjust setting of air discharge grilles and return air dampers, etc.

j) Check operation and interlocking of extract and fresh air supply fans (where appropriate).

k) Check and adjust air flow failure switch or switches and gas low pressure cut-off switches.

l) Check for correct connection and operation of all external components, e.g. thermostats, time switches, damper interlocks.

m) Check the gas tightness of the connections and pipework on the heater, using leak detection fluid.

n) Ensure that the gas installation pipework to the appliance has been tested for gas tightness and that the gas installation has been purged correctly.

NOTE Guidance is given in IGE/UP/1, "Strength and tightness testing and direct purging of industrial and commercial gas installations" [39], and IGEM/UP/1A, "Strength and tightness testing and direct purging of small, low pressure industrial and commercial natural gas installations" [40].

o) Ascertain from the appropriate gas supplier or the customer that the meter installation is operational.

Annex C (informative)

Typical live run checks

The following is a typical list of live run checks which should be carried out in the commissioning procedure.

a) After a faultless dry run, make gas available to the start gas burner of the heater to check that the ignition system is operating correctly; isolation of the main burner gas supply is necessary for this.

b) Simulate pilot or start gas flame failure and check that the flame safeguard system proceeds to lockout, e.g. by turning off the pilot or start gas supply.

c) After checking that the start gas flame is correctly sited and adequate to light the main flame, then allow gas to flow to the burner after also having ensured that there is adequate combustion air available. If the main flame fails to ignite, repeat the complete lighting procedure whilst ensuring that adequate time is allowed to purge the combustion chamber.

d) Carry out combustion analysis and adjust in accordance with the manufacturer's instructions.

NOTE See Annex C in BS EN 525:2009.

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