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British Standard Specification for
Indirect gas fired forced convection air heaters
for space heating (60 kW up to 2 MW input) :
safety and performance requirements (excluding
electrical requirements) (2nd family gases)

Spécification des générateurs de pulseurs d'air chaud, utilisant les combustibles gazeux, pour le chauffage des locaux (débit calorifique 60 kW à 2 MW): exigences de sécurité et de fonctionnement (à l'exclusion des exigences concernant le circuit électrique) (gaz de la deuxième famille)

Spezifikation für gasbefeuerte Wärmeluftherzeuger, mit Wärmeaustauscher, für Raumheizung (Wärmebelastung 60 kW bis 2 MW): Sicherheits- und Betriebsanforderungen (mit Ausnahme von elektrischen Anforderungen) (Gase der zweiten Familie)

Contents

	Page		Page
Foreword	1	16. Manual gas valves	9
Cooperating organizations	Back cover	17. Automatic controls	10
Specification		17.1 General	10
1. Scope	2	17.2 Governors	10
2. References	2	17.3 Gas strainers	10
3. Definitions	2	17.4 Safety shut-off valves	10
4. Classification of appliances	3	17.5 Combustion air, pre-purge and post-purge	11
4.1 By category	3	17.6 Flame supervision system	11
4.2 By flue type	3	17.7 Pilot or start-gas flame establishment	12
5. General requirements	3	17.8 Main flame establishment	13
6. General conditions of test	3	17.9 Air/gas ratio control for appliances with forced or mechanically induced draught burners	14
6.1 Test room	3	17.10 Thermostats and control of air temperature	14
6.2 Preparation of appliance for testing	3	18. Motors and fans	14
6.3 Test procedure	3	18.1 General	14
7. Design and construction	3	18.2 Fan motor temperature	15
7.1 All appliances	3	18.3 Lubrication	15
7.2 Appliances designed for permanent outdoor installation	5	18.4 Marking	15
8. Soundness	5	19. Electricity supply	15
8.1 General	5	20. Manufacturer's instructions	15
8.2 Complete assembly	5	20.1 General	15
9. Heat input	6	20.2 Installation instructions	15
9.1 Measurement	6	20.3 Servicing instructions	16
9.2 Tolerance	6	20.4 User's instructions	16
9.3 Adjustment	6	21. Facilities for commissioning and testing	16
10. Combustion	6	22. Identification and marking	16
10.1 Combustion requirements	6	22.1 General	16
10.2 Methods of analysis	7	22.2 Data plate	16
11. Ignition	7	22.3 Name badge	16
11.1 Pilot burners and ignition devices	7	22.4 Appliance parts	16
11.2 Ignition performance: burner systems with permanent pilots	7	22.5 Electrical data	16
11.3 Ignition performance: burner systems without permanent pilots	8	22.6 Warning notices	17
12. Flame stability	8	22.7 Lighting instructions	17
12.1 Still air conditions	8	23. Air handling	17
12.2 Abnormal draught conditions (natural draught appliances)	8	23.1 Air flow rate	17
12.3 Leakage characteristics	8	23.2 Air flow adjustment	17
13. Flue system	8	24. Combustion chamber pressure reliefs	17
13.1 Effectiveness of flue system	8	25. Thermal efficiency	17
13.2 Flue connections	8	25.1 Efficiency	17
13.3 Flue breaks	8	25.2 Heat input	18
13.4 Induced draught fans (fan-assisted flue systems)	8	25.3 Surface heat dissipation	18
13.5 Air heater designed for outdoor installation	8	26. Air delivery volume	19
14. External temperatures	9	26.1 Requirements	19
14.1 Surface temperatures	9	26.2 Method	19
14.2 Component temperatures	9	27. Air delivery temperature	19
15. Heat exchanger: working life	9	27.1 Requirement	19
15.1 Requirements	9	27.2 Method	19
15.2 Method	9	28. Weather resistance	19
		28.1 Requirements	19
		28.2 Rain test	19

Tables	Page	Figures	Page
1. Surface temperature rise	9	1. Paint scratch test apparatus	20
2. Valves required for natural draught systems	10	2. Test duct for air flow measurement	20
3. Valves required for forced and mechanically induced draught systems	11	3. Anti-swirl device	21
4. Flame supervision device drop-out times	12	4. Air flow regulation device	21
5. Fan motor windings: permissible temperature rises	15	5. Connecting bend	21
6. Enthalpy data for combustion products	18	6. Arrangement of spray heads and associated piping for rain test	22
7. Combustion data for test gas NGA	18	7. Details of spray head assembly and construction	23
8. Purge test gas			

Foreword

This British Standard has been prepared under the direction of the Gas Standards Committee.

It represents a part revision of BS 3561 : 1962; the requirements in BS 3561, applying to indirect gas fired forced convection air heaters, are therefore superseded.

In the preparation of this British Standard the opportunity has been taken to express values in metric (SI) units in accordance with the British Standards Institution's programme of metrication. Wherever possible, rounded metric values have been chosen.

Corresponding requirements for direct gas fired forced convection air heaters are specified in BS 5990.

Electrical requirements, applicable for both direct and indirect gas fired forced convection air heaters, are specified in BS 5986.

In anticipation of this standard being the subject of third party certification schemes, it provides for a claim by the appliance manufacturer of a numerical value for the thermal efficiency of a product model. The test authority will then ascertain that a sample submitted for type approval meets this claimed value within a specified test equipment tolerance. Any sample selected from subsequent production of the particular model will be expected to comply with a verification value, that will also take into account a specified production tolerance.

Another departure from established practice is the adoption of net instead of gross calorific value as the basis of thermal efficiency. This change is a consequence of European harmonization.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard Specification for

Indirect gas fired forced convection air heaters for space heating (60 kW up to 2 MW input) : safety and performance requirements (excluding electrical requirements) (2nd family gases)

1. Scope

This British Standard specifies detailed requirements, including safety and performance requirements and methods of test, for indirect gas fired forced convection air heaters having heat inputs from 60 kW up to 2 MW, intended for industrial and commercial applications.

The scope of this standard includes indirect gas fired forced convection air heaters for use both with and without ducting, and intended primarily for space heating applications.

This standard also specifies the requirements for indirect gas fired forced convection air heaters designed for permanent outdoor installation.

It applies to appliances designed to operate on normal low pressure district supplies of 2nd family gas.

This standard does not apply to portable and transportable indirect gas fired forced convection air heaters.

NOTE. For appliances fitted with gas boosters and/or flue dampers, additional requirements may apply.

2. References

The titles of the publications referred to in this standard are listed on the inside back cover.

3. Definitions

For the purposes of this British Standard, the following definitions, together with those given in BS 1179 and the relevant installation standards and codes of practice, apply.

3.1 air temperature control. A temperature-actuated control intended to maintain the temperature of the discharged air, the return air to the heater, or the air in the heated space between specified limits. This is the normal means of air temperature control.

3.2 automatic burner system. A burner system in which, when starting from the completely shut-down condition, the start-gas flame is established and the main gas valve(s) is actuated without manual intervention.

Automatic burners may have pilots that are interrupted or intermittent.

NOTE. This definition differs from that given in BS 1179 : Part 6.

3.3 automatic recycling. The automatic repetition of the starting-up sequence without manual intervention.

3.4 burner. A combustion system under the control of a single system of safety shut-off valves. An appliance may have more than one burner and a burner may comprise a number of separate nozzles or bars.

NOTE. This definition differs from that given in BS 1179 : Part 6.

3.5 forced convection air heater. An appliance designed to provide space heating from a central source by distributing

heated air, by means of an air-moving device, either through ducting or directly into the heated space.

3.6 hazardous condition. A condition that could result in damage external to the appliance and/or injury to personnel.

3.7 indirect fired air heater. An appliance in which the products of combustion are separately vented and do not mix with the heated air being supplied to the space.

3.8 lock-out. The safety shut-down condition of a control system such that restart cannot be accomplished without manual intervention.

3.9 minimum operational rate. 70 % of the minimum rate of the control system.

3.10 multifunctional control. An assembly comprising two or more gas control devices in addition to a gas tap and any gas rate adjuster within a single housing.

3.11 natural draught burner. A burner that does not employ a fan for the entrainment of air, either forced or induced. The term includes atmospheric injectors and neat gas burners.

NOTE. This definition differs from that given in BS 1179 : Part 6.

3.12 non-automatic burner system. A burner system that is non-automatic within the meaning of 3.2, i.e. a burner with a permanent pilot ignited under manual supervision.

3.13 overheat (limit) control. A temperature-actuated device preset and sealed by the manufacturer and designed to protect the appliance and its surroundings in the event of failure of the normal means of temperature control.

NOTE. This definition differs from that given in BS 1179 : Part 6.

3.14 rated heat input. The appliance manufacturer's declared heat input for the appropriate reference test gas.

3.15 safety shut-down. The action of shutting off all gas and ignition energy by means of a safety control such that restart takes place only after manual intervention or automatic recycling.

3.16 setting pressure. The pressure, measured at the pressure test point, that is specified by the manufacturer for the purpose of adjusting the appliance heat input.

3.17 start-gas flame. A flame established at the start-gas rate. This may be either a pilot flame or the main burner flame at reduced rate.

3.18 claimed efficiency (E_c). The net efficiency of an appliance claimed by the manufacturer.

3.19 test house efficiency (E_t). The net efficiency of an appliance measured at the test house on a sample submitted for type approval purposes.

3.20 verification efficiency (E_v). The net efficiency of an appliance measured during any surveillance or check testing of production appliances.

4. Classification of appliances

4.1 By category. BS 4947 describes the category system of appliance classification in which an appliance is denoted by a category number I, II or III according to the number of gas families that it is designed to burn, these families being identified by subscripts T, N and L for the 1st, 2nd and 3rd families respectively.

This standard is concerned with appliances of category I_N only.

4.2 By flue type. Appliances are also classified according to the flue system for which they are designed and the source of combustion air:

- type A : flueless appliances
- type B : open-flued appliances
- type C : room-sealed appliances
- type C₁ : balanced flue appliances
- type C₂ : se-duct appliances

This standard covers appliances of type B only.

5. General requirements

The appliance shall comply with the requirements of this standard when tested using the test gases specified for 2nd family gas. Full details of the test gases are given in BS 4947.

Any new features incorporated in an appliance for which no provision for testing is made in this standard shall not adversely affect the safe and correct operation of the appliance. The new features shall be examined in the light of the manufacturer's claims and instructions. The claims shall be checked against the instructions and shall be valid.

Notwithstanding the requirements in this standard, any new designs, materials and methods of assembly are permissible provided that at least equivalent results are achieved.

6. General conditions of test

6.1 Test room. The test room shall be adequately ventilated but free from draughts that are likely to affect the performance of the appliance.

The temperature in the test room shall be maintained at $20 \pm 5^\circ\text{C}$.

The air in the test room, and any external air supply, shall contain not more than 1000 p.p.m. (0.1 % (V/V)) of carbon dioxide or 10 p.p.m. (0.001 % (V/V)) of carbon monoxide.

6.2 Preparation of appliance for testing. The appliance shall be set up in accordance with the manufacturer's instructions, with particular reference to minimum declared clearances round the appliance. It shall then be adjusted in accordance with the manufacturer's instructions using test gas NGA at an inlet pressure of 17.5 mbar.*

Before any tests are made, the appliance shall be operated at its maximum rated heat input, using normal distributed gas, for a period sufficient to dry any insulation and remove any temporary finish that might interfere with observations.

Appliances with a vertical flue outlet shall be fitted with the minimum length of vertical secondary flue specified by the manufacturer and having the same nominal diameter as the flue outlet.

Appliances with a horizontal flue outlet shall be fitted in accordance with the manufacturer's instructions; these

shall include the maximum length of horizontal run and the method of adaptation to a vertical flue. Thereafter the vertical flue shall be fitted as above.

6.3 Test procedure. The appliance shall be examined for gas soundness before and after the tests specified in this standard.

The test results shall be deemed to be invalid unless the gas system is sound.

The appliance shall be at room temperature at the start of each test unless the test method specifies otherwise.

Unless the test method specifically requires otherwise, the appliance shall be operated at the design temperature rise $\pm 10\%$.

During testing, the initial adjustment of the appliance shall not be altered unless specifically required by the test method.

Precautions shall be taken to prevent thermostats or other variable controls from acting so as to interfere with the gas flow, except as necessitated by the test.

Gas test pressures shall be accurate to within ± 0.2 mbar and so controlled that the variation does not exceed ± 0.2 mbar.

In general, except for tests involving governor performance, the appliance governor may be put out of action and the specified test pressure obtained by adjustment of the gas pressure at the inlet to the appliance.

The heat input to the appliance shall be determined as specified in BS 4947.

7. Design and construction

7.1 All appliances

7.1.1 Materials, fittings and finishes. The appliance, including all its component parts, shall be soundly constructed and of a high standard of workmanship and finish.

Materials shall be of a type, quality and thickness appropriate to the application. In particular, all parts of the equipment shall be resistant to mechanical stresses, including shock, vibrationally or chemically or thermally induced, to which they may be exposed during any conditions of operation. Under normal conditions of use, maintenance and adjustment they shall show no changes that might adversely affect their function.

Such materials, fittings and finishes shall comply with the requirements of the relevant British Standards and shall all be appropriate to the conditions arising in the part of the appliance in which they are used.

The appliance and its components shall be free from swarf, grit or other foreign matter.

7.1.2 Flueways: natural draught burners. For air heaters fitted with natural draught burners, the combustion chamber and flueways shall be so designed that there is no descending section that is capable of creating reverse flows.

7.1.3 Component location. Parts that are intended to be removable for maintenance or cleaning shall be readily accessible, shall be easy to assemble correctly and impossible to assemble incorrectly where incorrect

*1 mbar = $100 \text{ N/m}^2 = 0.1 \text{ kPa}$.

assembly would create a hazardous condition or result in damage to the appliance and its controls.

The burner(s) shall be positively located and so arranged that misalignment cannot occur.

It shall not be possible to loosen complete burner assemblies, jets or injectors without the use of tools.

7.1.4 Injectors and jets. Injector and jet orifice areas shall be non-adjustable.

7.1.5 Gas rate adjusters. Adjustable gas rate adjusters shall be readily distinguishable from other manual valves. The setting of adjusters shall be protected by a method that discourages unauthorized adjustment.

7.1.6 Materials in contact with gas. Copper tubing shall not be used where it is likely to be exposed to temperatures above 100 °C.

Solder that has a melting point below 450 °C after application shall not be used for gas-carrying parts.

7.1.7 Aeration adjustment (natural draught burners). Any means of adjusting the primary aeration of natural draught burners shall be preset and locked by the manufacturer.

7.1.8 Insulation. Thermal or acoustic insulation shall be non-combustible in accordance with the requirements of BS 476 : Part 4, shall be securely located and shall be protected against mechanical damage, condensate and vermin.

Gas-carrying parts in contact with, or passing through, insulating material shall be adequately protected against possible corrosive effects of the insulant.

7.1.9 Fire properties. The appliance shall, wherever possible, be constructed of materials that are non-combustible in accordance with the requirements of BS 476 : Part 4. Any coating that may be applied to the outside surface of the appliance shall have class 1 surface spread of flame characteristics when tested on the substrate according to the requirements of BS 476 : Part 7.

Air filter material shall possess ignitability characteristics designated 'P' when tested in accordance with BS 476 : Part 5.

7.1.10 Fan compartment. Access to the air fan compartment for maintenance shall not be possible without the use of tools.

Products of combustion shall not be drawn into the air distribution system either under normal operating conditions or when user access panels are removed.

7.1.11 Gas connections. Gas inlet connections shall be suitable for connection to one of the following:

- (a) tapered thread installation pipes in accordance with BS 21;
- (b) flanged pipes and fittings in accordance with BS 10 or BS 4504 : Parts 1 and 2.

7.1.12 Bolts and screws. Drillings for bolts and screws shall not connect with fuel gasways. The minimum wall thickness shall be at least 1 mm.

Self-tapping screws are not recommended, but where they are used to secure components that are removed during servicing, they shall be fitted with spire-type clips.

Where hexagon headed screws are used to secure components that are removed during servicing, they shall be provided with screwdriver slots, where possible, if this facilitates servicing.

7.1.13 Viewing port. Means shall be provided to allow observation of pilot and burner flames. If the means of observation is a viewing port, it shall, when located in an area of positive pressure and high temperature, be covered with heat resistant, toughened glass and sealed with a suitable heat resistant sealant.

7.1.14 Servicing. There shall be easy access to components and controls that may require servicing or adjustment. The appliance shall be fitted with access doors or removable panels to facilitate servicing. Such doors or panels shall comply with the requirements of clause 24.

In addition, union or flanged connections shall be provided to permit the removal of the burner assembly from the appliance and disconnection of the appliance from the gas supply.

Appliances shall be so designed that periodic servicing, inspection or parts replacement are not normally required more than once per year. Any known deviation from this requirement shall be the subject of negotiation between the manufacturer and the testing authority.

NOTE. Filters may require changing or cleaning more often than once per year, and this is acceptable.

A burner that can be retracted from the combustion chamber or is provided with swivel flanges to allow the burner to be swivelled from the combustion chamber shall be provided with a safety device to prevent accidental swivelling. If the burner can be retracted or swivelled without the use of tools it shall also be provided with an interlock to cause lock-out if the burner is retracted or swivelled from the firing position.

7.1.15 Panel anchorage. Panels that are normally removed for servicing shall be fitted with anchor lines where the appliance is intended to be installed other than at floor level. This requirement shall be deemed to be satisfied if suitable hinges are fitted.

7.1.16 Unions and flanges. Unions in fuel gasways shall be of the cone or spherical-seated type. Flange joints shall include a gasket resistant to the action of components of the gas and suitable for the temperature to which it is likely to be exposed.

7.1.17 Flexible pipes. Flexible pipes shall be metal armoured and have screwed or flanged connections. Flexible pipes shall withstand at least three times the working pressure with a minimum of 3.5 bar at both maximum and minimum service temperatures. There shall be electrical continuity across such pipes. There shall be a manual isolating valve in a readily accessible position upstream of the inlet of any section of flexible pipe.

7.1.18 Components and controls. Components and controls fitted to the appliance shall comply with the requirements of relevant British Standards.

Gas-carrying controls shall be sited externally to the air duct so as to prevent ingress of gas into the discharged air.

Where controls are enclosed in a separate compartment, the compartment shall be adequately ventilated. The vent shall be so sited that it cannot be obstructed by foreign matter, birds, etc.

Bypasses shall not be provided around any item of safety equipment.

7.1.19 Air inlets. Where the inlet air is intended to be ducted to the heater, the appliance shall be provided with flanged or spigot connections on the air inlet. If necessary the manufacturer shall supply a suitable adaptor in order to meet this requirement.

7.1.20 Air outlets. The air outlet(s) of a ductless heater shall be fitted with directional louvres that are capable of adjustment between horizontal discharge and discharge at an angle of at least 45° downwards from the horizontal. When the louvres are in the position of maximum closure, the minimum requirements for functional purposes shall be satisfied.

Ducted air heaters shall have air outlets equipped with flanges or spigots to facilitate connection of ductwork or flexible connectors.

7.1.21 Facility for remote control. Appliances shall be capable of being controlled remotely by means of thermostats and a time control.

7.1.22 Durability of protective finishes

7.1.22.1 General. Materials that are used for the construction of parts that are not normally subject to service and maintenance shall be adequately protected against corrosion.

7.1.22.2 Galvanized parts. Galvanized parts shall comply with the requirements of BS 729, BS 2989 or BS 4921 as appropriate.

Galvanized parts, or samples thereof, shall be subjected to non-destructive tests as specified in BS 1706 or other relevant standards and shall comply with the requirements of those standards.

7.1.22.3 Painted and plastics coated parts. Painted or plastics coated surfaces shall comply with the following requirements.

(a) *Resistance to heating.* There shall be no appreciable change of colour on any part of the appliance, and the finish shall not become tacky or show other signs of deterioration at the end of the drying out period as specified in 6.2.

NOTE. This requirement does not apply to parts that come into direct contact with the flame.

(b) *Resistance to abrasion.* Surfaces shall be tested for resistance to scratching. The hardness shall be such that the protective film is not penetrated when subjected to the following test. The scratch shall not have a width greater than 1 mm at any point along its length.

Method. Apply the apparatus (see figure 1) to the surface under test and move the ball, after loading with a force of 10 N, at 30 mm/s to 40 mm/s relative to the surface. If the indicator lamp lights, the surface is deemed to have been penetrated. A metallic paint applied directly to a metal surface will cause the lamp to light without penetration and, in this case, the paint surface should be visually examined for penetration. Clean the ball after each test and inspect it frequently to verify that it remains a 1 mm sphere.

7.1.22.4 Plated parts. Electroplated metal parts shall have a standard of adhesion and resistance to corrosion equivalent to the requirements of BS 1224 for service condition no. 2 (appliance designed for indoor installation) or service condition no. 3 (appliance designed for permanent outdoor installation), as appropriate.

7.1.23 Noise. Noise emission shall not be excessive with regard to the application of the air heater.

7.1.24 Smell. After the initial burning-off period the appliance shall not give rise to any unpleasant smell.

7.1.25 Disposal of condensate. An appliance with a claimed thermal efficiency in excess of 92 % (based on the net calorific value) shall be provided with means for collection and disposal of condensate.

7.2 Appliances designed for permanent outdoor installation

7.2.1 General. Appliances designed for permanent outdoor installation shall be so constructed that they are fully protected against the rigours of the environmental conditions under which they are expected to operate.

NOTE. The top of outdoor units should preferably be so shaped as to prevent the collection of water.

7.2.2 Combustion air inlets. Combustion air inlets shall be so sited that their lowest edge is at least 500 mm above the base of the appliance, or 500 mm above floor level if this is specified in the manufacturer's installation instructions.

Air inlets shall be so designed as to avoid accidental blockage.

7.2.3 Ventilation. The appliance and its casing shall be adequately ventilated.

7.2.4 Access panels and doors. Access panels and doors and such insulation as needs to be removed during normal servicing shall be so designed that repeated removal and replacement does not damage or impair the weatherproofing of the appliance.

7.2.5 Dimensions of openings. No dimension of any opening from the inside of the appliance to the outside air shall be less than 6.5 mm, nor shall any opening permit the entry of a ball of diameter 16 mm applied with a force of 5 N.

7.2.6 Fixing screws. External panels shall be fixed using only hexagon headed screws, except in the case of access panels, which may be fixed by approved hinges and door catches.

8. Soundness

8.1 General. All gas-carrying parts of the appliance shall be sound and, when connected, shall form a complete assembly that is sound. The test specified in 8.2 shall be carried out on the complete assembly.

Where automatic soundness proving systems are fitted, means shall be provided to enable the soundness test specified in 8.2 to be carried out.

8.2 Complete assembly

8.2.1 Requirements. That part of the system between the inlet and last shut-off valve(s), whether automatic or otherwise, shall be sound when tested to 1.5 times the manufacturer's stated maximum inlet pressure, or 50 mbar, whichever is the greater.

Gas-carrying parts downstream of the last shut-off valve(s) shall be tested for external leakage at the setting pressure using any suitable method, and shall be sound.

These requirements shall be deemed to be satisfied if the leakage rate over a period of 1 min does not exceed 85 cm³/h.

8.2.2 Method. Connect to the appliance inlet an air supply maintained constant at the appropriate pressure and embodying a suitable meter for measuring air flow. Subject all gas-carrying parts of the appliance to this pressure under the following conditions:

- (a) with all gas valves in the CLOSED position;
- (b) with all gas valves in the OPEN position, the flame supervision device maintained, by suitable means, in the open position and all igniters or pilots capped off.

NOTE. Care should be taken to ensure that any means (e.g. thermal or mechanical) used to maintain the flame safeguard in the open position is compatible with the normal operation of the control.

9. Heat input

9.1 Measurement. For the purposes of this British Standard, the heat input is that which would be obtained with a reference gas having a Wobbe number, under standard conditions of temperature, pressure and humidity, corresponding to the mean Wobbe number of the appropriate gas family (see BS 4947).

The heat input shall be measured with the appliance at thermal equilibrium and in its normal operating condition.

9.2 Tolerance. Burners operated individually or in combination shall have a heat input within $\pm 5\%$ of that stated by the manufacturer when operated at the manufacturer's stated setting pressure.

With the air heater adjusted to give the rated heat input at an inlet pressure of 17.5 mbar, the actual heat input shall be within $\pm 10\%$ of the rated heat input over the range of inlet pressure from 15.0 mbar to 25.0 mbar.

With the inlet pressure adjusted to 17.5 mbar on test gas NGA, the heat input shall not exceed 120 % of the rated heat input when:

- (a) any governor adjustment accessible for the setting of rating (i.e. one that does not involve the use of tools) is at its maximum setting;
- (b) all other gas rate adjusters are fully open.

9.3 Adjustment. Any means of adjustment of the heat input to the appliance shall be preset by the manufacturer at the maximum rated heat input and locked or sealed to discourage unauthorized interference.

10. Combustion

10.1 Combustion requirements

10.1.1 General. When the appliance is tested under the conditions described in 10.1.2 and 10.1.3 the carbon monoxide content in the dry, air-free products of combustion shall not exceed:

- (a) 0.1 % when the heater is supplied with test gas NGA under the still air and adverse flue conditions described in 10.1.2 and 10.1.3;
- (b) 0.2 % when the heater is supplied with the incomplete combustion test gas NGB.

The general test method is as follows.

The appliance shall be set up in accordance with the relevant requirements of 6.2.

Tests shall be made at a sufficient number of heat input rates to determine the combustion performance over the whole of the prescribed range. No extrapolation shall be made.

The products of combustion shall be collected in such a manner as to ensure a representative sample, and the carbon monoxide and carbon dioxide contents determined.

The carbon monoxide content relative to the dry air-free products of combustion is given by the equation:

$$[\text{CO}] = [\text{CO}_2]_{\text{st}} \times \frac{[\text{CO}]_{\text{m}}}{[\text{CO}_2]_{\text{m}}}$$

where

$[\text{CO}]$ is the percentage by volume of carbon monoxide in the dry, air-free, products of combustion;

$[\text{CO}_2]_{\text{st}}$ is the theoretical maximum percentage by volume of carbon dioxide in the dry, air-free, products of combustion;

$[\text{CO}]_{\text{m}}$ and $[\text{CO}_2]_{\text{m}}$ are the carbon monoxide and carbon dioxide concentrations measured in the sample during the combustion test, both being expressed in the same units.

The values of the maximum theoretical carbon dioxide content of the dry air-free products are given for the test gases in the following table.

Test gas	Theoretical CO_2 content
	%
NGA	11.7
NGB	12.0

10.1.2 Combustion under still air conditions. The combustion requirement shall be satisfied when the heater is tested, under still air conditions, at the inputs shown in the following table.

Test gas	Heat input
NGA	1.05 x maximum rated input
NGB	Setting pressure corresponding to 1.05 x maximum rated input when using NGA

In addition, for appliances designed to operate over a range of heat input (i.e. a range rated appliance) the combustion requirements shall be satisfied when the appliance is adjusted to each input rate within the specified range and with the air flow rate adjusted to give the manufacturer's specified air flow rate corresponding to each input rate.

10.1.3 Combustion under adverse flue conditions

10.1.3.1 Heater fitted with natural draught burners.

With the heater operating at the rated heat input and utilizing test gas NGA, the secondary flue shall be subjected to updraughts and downdraughts of up to 3 m/s.

Under these conditions the CO content of the dry air-free products of combustion shall not exceed 0.1 %; there shall be no appreciable distortion or disturbance of the main burner flames and pilots shall remain stable. This requirement shall be deemed to be satisfied if the heater proceeds to safety shut-down before the carbon monoxide content reaches 0.1 %.

The flame supervision device shall continue to function normally and there shall be no spillage of products of combustion other than from the draught diverter or stabilizer.

To reduce the effect of turbulence when testing under updraught conditions, the measuring device shall be inserted at a point above the flue break not less than the equivalent length of 10 times the nominal diameter of the outlet flue connection. For downdraught tests, the measuring device shall be inserted in the flue near to the flue break.

With the heater operating at the rated heat input on test gas NGA and fitted with the minimum length of vertical secondary flue specified by the manufacturer (in the absence of a specification by the manufacturer a 1 m length of flue shall be used for test purposes) with the flue outlet capped, the CO content of the dry air-free products of combustion shall not exceed 0.1 %.

10.1.3.2 Heater fitted with forced or induced draught burners. With the heater operating at the rated heat input and utilizing test gas NGA, and with the minimum length of flue specified by the manufacturer, the top of the flue shall be progressively blocked until the pressure at the base of the flue increases by 0.5 mbar. Under these conditions the carbon monoxide in the dry air-free products shall not exceed 0.1 %. This requirement shall be deemed to be satisfied if the heater proceeds to safety shut-down before the carbon monoxide percentage reaches 0.1 %.

This requirement shall also be deemed to be satisfied if the combustion air fan total pressure is greater than 2.5 mbar.

10.2 Methods of analysis

10.2.1 Carbon dioxide*. The carbon dioxide content of the flue products shall be measured by means of a non-dispersive infra-red analyser or by any other method giving at least an equivalent accuracy, e.g. gas chromatography. The carbon dioxide content shall be determined to an accuracy of ± 5 % of the actual reading.

10.2.2 Carbon monoxide*. The carbon monoxide content of the flue products shall be measured by means of a suitably sensitive non-dispersive infra-red analyser or by any other method giving at least an equivalent accuracy, e.g. gas chromatography. The carbon monoxide content shall be determined to an accuracy of ± 10 % of the actual reading.

11. Ignition

11.1 Pilot burners and ignition devices

11.1.1 General. All pilots shall be protected by design or position against diminution or extinction, e.g. by products of combustion, overheating, condensation or particulate matter.

11.1.2 Pilot supply. The gas supply to a pilot burner shall be taken from such a position as to avoid starvation that would be likely to impair ignition when gas is admitted to the main burner, and shall be fitted with a manual isolation valve.

This requirement shall be deemed to be satisfied if a multi-functional control is fitted.

Pilot supply lines shall be connected to the main gas line in such a way as to preclude blockage of the pilot line by gas-borne dust, dirt or condensate.

The gas supply to a permanent pilot shall be protected against blockage by gas-borne particulate matter.

11.1.3 Pilot and detector location. Pilots, ignition devices and their mountings shall be so designed that they can only be located rigidly and correctly in relation to every component and burner in conjunction with which they are designed to operate.

For ladder pilots and extended surface burners, e.g. multi-bar burners over 1 m in length, and for main burners directly ignited at a reduced rate, the flame detector(s) shall be located at a point(s) distant from the point of ignition such that flame run is proven.

11.2 Ignition performance: burner systems with permanent pilots

11.2.1 Pilot ignition. The pilot shall ignite smoothly and the flame shall not light back, lift, roar, cause discoloration on any external surface of the appliance, deposit soot, or smell when tested over the following range of appliance inlet pressures and test gases.

Test gases	Pressure range
NGA, NGB, NGC, NGD	12.5 mbar to 27.5 mbar

Any adjustable pilot shall have been previously adjusted in accordance with the manufacturer's instructions and shall not be re-adjusted during the test.

During commissioning, servicing and normal operation it shall be possible rapidly to determine that the pilot is alight.

11.2.2 Main burner ignition. Ignition of the main burner shall be smooth and the flame shall carry over to all ports. Ignition shall be checked with the appliance operating at its minimum stated and maximum rated inputs with respect to reference test gas NGA. The following test gases shall be used:

NGA, NGB, NGC, NGD.

11.2.3 Pilot flame reduction. The arrangement of the flame safeguard system shall be such that, in the event of the pilot gas rate being reduced to 75 % of the heat input required to hold open the valve of the flame safeguard system, ignition of the main gas shall be achieved without undue noise, flame roll-out or light-back with the appliance operating at its minimum stated and maximum rated inputs with respect to reference test gas NGA. At the start of each test the appliance shall be in the cold condition.

The following test gas shall be used:

NGA.

11.2.4 Main burner ignition at reduced inlet pressure. With the appliance adjusted in accordance with the requirements of 6.2, ignition of the main gas shall occur smoothly when the inlet pressure is reduced to 12.5 mbar and the gas is ignited in accordance with the manufacturer's instructions.

When the inlet pressure is progressively reduced below 12.5 mbar, the gas supply to the main burner shall be automatically shut off before ignition becomes violent.

Confirmatory tests shall be carried out with the appliance in the hot condition and also in the cold condition on test gas NGA.

* Suitable methods of analysis for carbon dioxide and carbon monoxide are described in BS 1736.

11.3 Ignition performance: burner systems without permanent pilots. Ignition and establishment of the start-gas and main gas flames shall be:

- (a) smooth and reliable;
- (b) without undue noise;
- (c) without damage to the appliance;
- (d) without flame roll-out or light-back.

These requirements shall be satisfied with the air heater operating at its minimum stated and maximum rated heat inputs relative to test gas NGA both when cold and in the fully heated condition using test gases NGA, NGB, NGC and NGD.

Ignition of the main burner shall be achieved as required in (a) to (d) at all conditions that allow the flame safeguard system to pass main gas to the burner. This requirement shall be satisfied with the appliance operating at its minimum stated and maximum rated heat inputs using test gas NGA, both in the cold and in the fully heated conditions.

The appliance shall continue to ignite and operate safely at inlet gas pressures down to 12.5 mbar, and below this pressure shall either continue to ignite and operate safely or proceed to safety shut-down.

12. Flame stability

12.1 Still air conditions

12.1.1 Requirement. The main burner flames shall remain stable without lighting back to the injector(s) or lifting off when operated on the light-back and lift limit test gases under the following conditions.

Test gas	Conditions
NGC	Minimum operational rate to the maximum rated heat input
NGD	Maximum rated input

12.1.2 Method. Adjust the appliance at thermal equilibrium on test gas NGA. Substitute the appropriate test gas NGC or NGD without further adjustment to the appliance or the supply pressure and turn off the appliance. With the appliance in the cold condition, relight the appliance and observe the flames on the main burner until thermal equilibrium is reached.

12.2 Abnormal draught conditions (natural draught appliances)

12.2.1 Requirement for internal installations. With the appliance set up in its normal operating condition, a wind of 2 m/s in a horizontal plane at the burner level and centred on the burner shall not cause permanent flame lift, blow-off or light-back of either the pilot or the main burner at input rates from the minimum stated heat input to the maximum rated input. This test shall be carried out using test gas NGA.

12.2.2 Requirement for external installations. In the special case of an appliance designed for external installation, the appliance shall be subjected to a wind of 15 m/s and shall comply with the requirements of 12.2.1.

12.2.3 Method for internal and external installations. A fan of at least 0.25 m² cross-sectional area is used and the distance from it at which the wind speed is 2 m/s, for internal

installations, or 15 m/s for external installations, is found using a vane anemometer.

The fan is then placed to give this wind speed at the air heater with the air stream directed at the heater. A shield, large enough to cover the fan outlet, is placed downstream of the fan and between the fan and the heater.

Immediately after lighting the heater, the shield is removed for periods of 3 s so that gusting is produced. This test is repeated at steps of 30° round the heater in the horizontal plane.

During the test the draught diverter shall be protected from the effects of the fan wind.

12.3 Leakage characteristics

12.3.1 Ductless air heaters. When the air outlet louvres of a ductless air heater are set in the position of maximum closure and when the appliance is operated at its maximum rated heat input on test gas NGA, there shall be no observable interference with the main burner flames nor shall there be any appreciable change in the carbon dioxide content of the combustion products in the primary flue.

12.3.2 Ducted air heaters. When a ducted air heater is operated against a static pressure of 0.5 mbar in the outlet air duct and when the appliance is operated at its maximum rated heat input on test gas NGA, there shall be no observable interference with the main burner flames nor shall there be any appreciable change in the carbon dioxide content of the combustion products in the primary flue.

13. Flue system

13.1 Effectiveness of flue system. When the appliance is installed and operated in accordance with the manufacturer's instructions (6.2), there shall be no escape of combustion products other than to the chimney flue. The manufacturer shall specify the minimum effective height of chimney flue, where appropriate, and/or the minimum flue draught required.

13.2 Flue connections. Where the flue and its termination are not an integral part of the appliance:

- (a) the flue outlet of the appliance shall be suitable for connection to round flue pipes complying with the requirements of BS 715, BS 567 or BS 835;
- (b) the flue outlet shall be of the socket type having a minimum depth of 25 mm, or be designed to prevent condensation from running down the outside of the appliance.

13.3 Flue breaks. A natural draught appliance shall incorporate a draught diverter or a stabilizer of the double swing type.

13.4 Induced draught fans. When a fan is integral with the heater to assist in the supply of combustion air, the heater shall comply with the requirements set down for automatic forced and induced draught burners (see 17.6.3, 17.7.3, 17.8.3).

13.5 Air heater designed for outdoor installation

13.5.1 Requirements. The flue outlet shall be so designed and positioned that it cannot be obstructed (e.g. by products of corrosion, air borne dirt, leaves or snow, etc.) and that staining of adjacent surfaces is minimized.

The flue outlet, if integral with the heater, shall be protected against the ingress of rain or snow. Any opening in the protective guard shall not permit the entry of a ball 16 mm in diameter applied with a force of 5 N.