PAS 42:2002

Method of test for establishing the efficiency of decorative fuel effect gas fires

ICS 91.100.20

This Product Assessment Specification comes into effect on 8 May 2002

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 33330 2

Contents

Foreword

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This document has been prepared by the Technical Panel of the Gas Fire Group sector of the Society of British Gas Industries as a method of measuring the thermal efficiency of decorative fuel effect gas fires.

This document describes a method of measuring the efficiency of decorative fuel effect gas fires. It complements BS EN 509, which includes requirements and test methods for construction, safety and marking of decorative fuel effect gas fires. The use of this method is not required by BS EN 509, which does not include requirements for the efficiency of decorative fuel effect gas fires.

These test methods are based on existing, accepted techniques for obtaining the output on other types of gas fire. These methods have been adapted and modified to be appropriate for a decorative fuel effect gas fire as described in **2.4**.

It is intended that this document will allow accurate and reproducible efficiencies to be calculated to enable fair comparisons between decorative fuel effect gas fires of differing designs, and also between decorative fuel effect gas fires and gas fires of other categories.

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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 13 and a back cover.

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1 Scope

This Product Assessment Specification specifies requirements and test methods for measuring the efficiency of decorative fuel effect gas fires not exceeding a nominal heat input of 20 kW (based on net calorific value), hereinafter referred to as appliances.

Generally the safety and construction of these appliances is specified in European Standard BS EN 509.

This document is not applicable to the following:

a) radiant convector and inset live fuel effect fires specified in BS 7977-1;

b) closed fronted and balanced flue appliances specified in BS EN 613;

c) appliances incorporating a fan to assist the transportation of combustion air and/or combustion gases covered by EN 1266 and prEN 13278.

2 Terms and definitions

For the purposes of this Product Assessment Specification the following definitions apply.

2.1
radiant convector [see Figure 1(a)]
gas fired appliance designed to heat a room mainly by the emission of air heated by convection. Such an appliance also contains vertical, or near vertical, mounted radiant elements designed to give maximum radiant output to the room. It is designed to be mounted on a hearth, floor or wall. It may be mounted wholly or partially inset into the void behind the fireplace opening

2.2
live fuel effect fire (LFE) [see Figure 1(a)]
gas fired appliance designed to heat a room mainly by the emission of air heated by convection. Such an appliance also contains radiant elements designed to simulate a solid fuel fire bed. It is designed to be mounted on a hearth, floor or wall

2.3
inset live fuel effect fire (ILFE) [see Figure 1(b)]
live fuel effect fire (**2.2**) designed to be installed wholly or partially inset into the void behind the fireplace opening

2.4
decorative fuel effect gas fire [see Figure 1(c)]
gas fired appliance designed to simulate a solid fuel appliance for decorative purposes and intended to be installed so that the products of combustion pass unrestricted from the firebed to the chimney or flue

2.5 Gases

2.5.1 reference conditions

— for calorific values (temperature: 15 °C);

— for gas and air volumes dry (brought to 15 °C and to an absolute pressure of 1 013.25 bar)[1].

2.5.2
calorific value
quantity of heat produced by the complete combustion of gas, at a constant pressure equal to 1 013.25 bar, of unit volume or unit mass of gas, the constituents of the combustible mixture being taken at reference conditions and the products of combustion being corrected back to the reference conditions specified in **2.5.1**

A distinction is made between the following:

— the gross calorific value in which the water produced by combustion is assumed to be condensed (symbol H_s);

— the net calorific value in which the water produced by combustion is assumed to be in the vapour state (symbol H_i);

— units are either:

  — megajoules per cubic metre (MJ/m^3) of dry gas at reference conditions; or

  — megajoules per kilogram (MJ/kg) of dry gas.

2.5.3
relative density
ratio of the masses of dry gas and dry air at the same conditions of temperature and pressure (symbol: *d*)

2.5.4
Wobbe index
ratio of the calorific value of a gas per unit volume to the square root of its relative density under the same reference conditions. The Wobbe index is said to be gross or net according to whether the calorific value is the gross or net calorific value

— symbol: gross Wobbe index: W_s

— net Wobbe index: W_i

— units are either:

  — megajoules per cubic metre (MJ/m^3) of dry gas at the reference conditions; or

  — megajoules per kilogram (MJ/kg) of dry gas.

1) 1 bar = 10^5 N/m^2

2.6
normal pressure
pressure under which appliances operate in nominal conditions, when they are supplied with the corresponding reference gas

2.7
nominal heat input
value of heat input declared by the manufacturer

3 Determination of heat input

Before any tests, operate the appliance at its normal pressure for a period sufficient to dry any insulation and remove any temporary finish, which may interfere with observations.

The nominal gas rate is the volumetric rate V_N or mass rate M_N corresponding to the nominal heat input obtained with reference gas under reference conditions (dry gas, 15 °C, 1 013.25 bar).

See Table 1 for characteristics of the test gases.

The nominal heat input Q_n in kilowatts (kW) is measured with the appliance at thermal equilibrium and is given by one of the following expressions:

$$Q_n = 0.278\, M_N \cdot H_i$$

$$Q_n = 0.278\, V_N \cdot H_i$$

where:

M_N is the nominal mass rate in kilograms per hour (kg/h) obtained under reference conditions (dry gas, 15 °C, 1 013.25 bar);

V_N is the nominal volumetric rate in cubic metres per hour (m^3/h) obtained under reference conditions (dry gas, 15 °C, 1 013.25 bar);

H_i is the net calorific value of the reference gas in megajoules per kilogram (MJ/kg) (1st expression) or in megajoules per cubic metre (MJ/m^3) (dry gas, 15 °C, 1 013.25 bar) (2nd expression).

The mass and volume rates correspond to a measurement and to a flow of reference gas under reference conditions, i.e. assuming the gas to be dry, at 15 °C and under 1 013.25 bar pressure. In practice the values of mass and volumetric rates do not correspond to these reference conditions, and have therefore to be corrected using the following equations to bring them to the values that would have been obtained had the reference conditions existed during the tests, at the outlet of the injector[2)].

When the determination is made by mass (3rd family gas), the corrected mass rate is calculated from the following equation:

$$M_o = M\sqrt{\frac{(1013.25 + p)}{(p_a + p)} \times \frac{273 + t_g}{288} \times \frac{d_r}{d}}$$

When the determination is made from the volumetric rate, the following correction equation should be used:

[2)] Special precautions should be taken when the measurement of volumes of dry gases is made with a wet (water filled) meter. For third family gases, if the rate is measured by volume, a dry meter should be used.

$$V_o = V\sqrt{\frac{(1013.25+p)}{(1013.25)} \times \frac{(p_a+p)}{1013.25} \times \frac{228}{273+t_g} \times \frac{d}{d_r}}$$

The corrected mass rate should be calculated from the following equation:

$$M_o = 1.226 \times V_o \times d$$

where:

M_o is the mass rate under reference conditions;

M is the mass rate obtained under test conditions;

V_o is the volumetric rate under reference conditions at the appliance inlet;

V is the volumetric rate under test conditions (measured at, or corrected to pressure p and temperature t_g);

p_a is the atmospheric pressure in bar;

p is the gas supply pressure in bar;

t_g is the temperature of the gas at the appliance inlet in °C;

d is the density of dry test gas relative to that of dry air;

d_r is the density of reference gas relative to that of dry air.

These are the equations that are used to calculate from the mass (M) or volumetric (V) rates, measured under test conditions, the corresponding M_o or V_o rates that would have been obtained under reference conditions, and it is these values, M_o and V_o, that are compared with the values M_N and V_N, calculated from the nominal heat input, using the equations specified earlier in this clause.

These equations are applicable if the test gas used is dry.

If a wet (water filled) meter is used or if the gas used is saturated, the value d (density of dry gas in relation to dry air) is replaced by the value of the density of the wet gas d_h specified in the following equation:

$$d_h = \frac{d \times (p_a + p - W) + 0.622 \times W}{p_a + p}$$

where:

W is the saturation vapour pressure of the test gas expressed in bar at temperature t_g.

4 Correct evacuation of combustion products

4.1 Requirement

When tested in accordance with **4.2** any leakage of products from the appliance shall not exceed the ambient CO_2 by more than 0.02 % (v/v).

4.2 Test method

4.2.1 The appliance shall be installed in the efficiency test rig in accordance with **5.2** and **5.3**.

Any bricks or imitation fuel not positively located with respect to the burner and to each other shall be arranged at the limit of their movement.

NOTE Due note should be taken of the manufacturer's instructions and the ease with which refractories can be positioned. If it is obvious that any particular arrangement is not in accordance with the manufacturer's instructions for assembly of the fuel bed, the arrangement should not be used for testing purposes.

4.2.2 Tests shall be carried out after the appliance has been heated for 1 h at the nominal heat input using reference gas or any other gas of suitable quality.

NOTE Reference gas is expensive and consequently normal line gas, i.e. the gas supplied to the building, is used to heat the appliance and then the appliance is switched to the reference gas for the test.

A suitable form of spillage detector is a 6 mm diameter sampling tube with holes drilled at 50 mm centres. The sampling holes shall be situated only over the fireplace opening. The sampling tube shall be positioned 5 mm above the top edge of the opening in the test box.

Sample leakage products across the opening of the test box and record the CO_2 concentration. Measure the ambient CO_2 concentration and calculate the difference between the two values.

Use instrumentation capable of measuring the CO_2 concentration of gas to an accuracy of 0.002 % (*v*/*v*).

5 Efficiency

5.1 General

The efficiency is based on net calorific value and is obtained with the appliance operating at its nominal heat input.

5.2 Test installation

The appliance should be installed on the efficiency test rig (see Figure 2) in accordance with the manufacturer's instructions. If, due to its design, the appliance is not compatible with the dimensions of the test box, then the box may be increased in size, in accordance with the manufacturer's instruction manual. Likewise, if the manufacturer specifies a larger flue (e.g. diameter and/or length greater than that shown in Figure 2) then the test flue shall also be made in accordance with the instructions. If the test is conducted with a larger diameter flue, the appliance manufacturer should provide the appropriate probe. Any unique flue and/or fireplace components necessary for the optimum installation of the appliance into the efficiency test rig shall be supplied by the manufacturer (e.g. purpose designed chair brick). Where the manufacturer's installation instructions specify a different size opening, then the manufacturer shall supply a sheet metal front panel with the required size of opening.

5.3 Initial adjustment of the appliance

Before the test is carried out the appliance should be fitted with the appropriate equipment [injector(s), fixed primary aerator restrictor(s), etc.] corresponding to the gas family for which the appliance is adjusted.

The supply pressures to be used in testing shall be as follows:

— natural gas (NG) (20 bar);

— propane (37 bar).

The heat input (measured in accordance with clause **3**) shall be within ± 2 % of the nominal heat input.

5.4 Clearance of products

Close the butterfly valve at the base of the flue (see Figure 2) until the appliance begins to spill its products into the room.

Open the butterfly valve until the appliance conforms to **4.1**. Measure and record the concentration of CO_2 in the flue.

Slowly open the butterfly valve until the CO_2 level in the flue is reduced by 10 % (*v*/*v*) from its previous reading.

5.5 Test

Operate the appliance for 1 h at the nominal heat input using reference gas and adjust the conditions in the flue in accordance with **5.4**.

Sample the products of combustion and measure the temperature 200 mm down from the upper end of the flue using the probe specified in Figure 3. The rate of sampling of the flue products shall be 10 l/min ± 10 %.

After 1 h determine the efficiency in accordance with **5.6**. The temperature of the room should be 20 °C ± 5 °C. Measure this temperature at a height of 1.5 m from the floor at least 3 m from the appliance with a thermometer which is protected against direct radiation from the appliance.

5.6 Determination of efficiency

The efficiency, n, refers to the net calorific value and is given by the following equation:

$$n = 100 - (q_1 + q_2)$$

where:

q_1 is the heat of the dry products of combustion (% of heat released per unit volume of gas);

q_2 is the heat of the water vapour contained in the products of combustion (% of heat released per unit volume of gas).

q_1 is given by the following equation:

$$q_1 = C_1 \times V_f \times \frac{t_2 - t_1}{H_i} \times 100$$

where:

C_1 is the mean specific heat of the dry products of combustion in megajoules per cubic metre Kelvin (MJ/m^3 K) (see Figure 4);

V_f is the volume of dry products of combustion per unit volume of gas at 1 013.25 bar and 15 ºC measured in m^3. V_f is calculated from the volume of CO_2 produced by the combustion of 1 m^3 of gas V_{CO_2} and from the CO_2 content of the products of combustion $V_{CO_2,M}$ (See the note to Table 1. for V_{CO_2} values).

$$V_f = \frac{V_{CO_2}}{V_{CO_2,M}} \times 100$$

t_2 is the average temperature of the products of combustion in degrees Celsius (°C);

t_1 is the average combustion air temperature in degrees Celsius (°C);

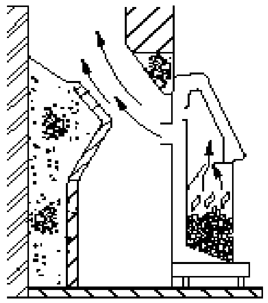
H_i is the net calorific value of the gas in megajoules per cubic metre (MJ/m^3);

q_2 is given by the following equation:

$$q_2 = 0.077 \times \frac{H_s - H_i}{H_i} \times (t_2 - t_1)$$

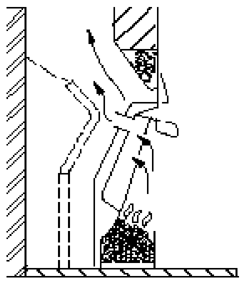
where:

H_s is the gross calorific value.

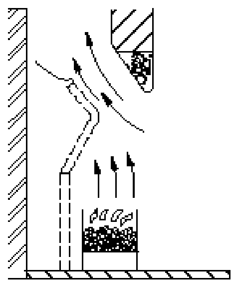


NOTE For this type of appliance the radiating surface can be either radiant or imitation fuel, the latter giving a live fuel effect.

(a) Radiant convector or live fuel effect fire



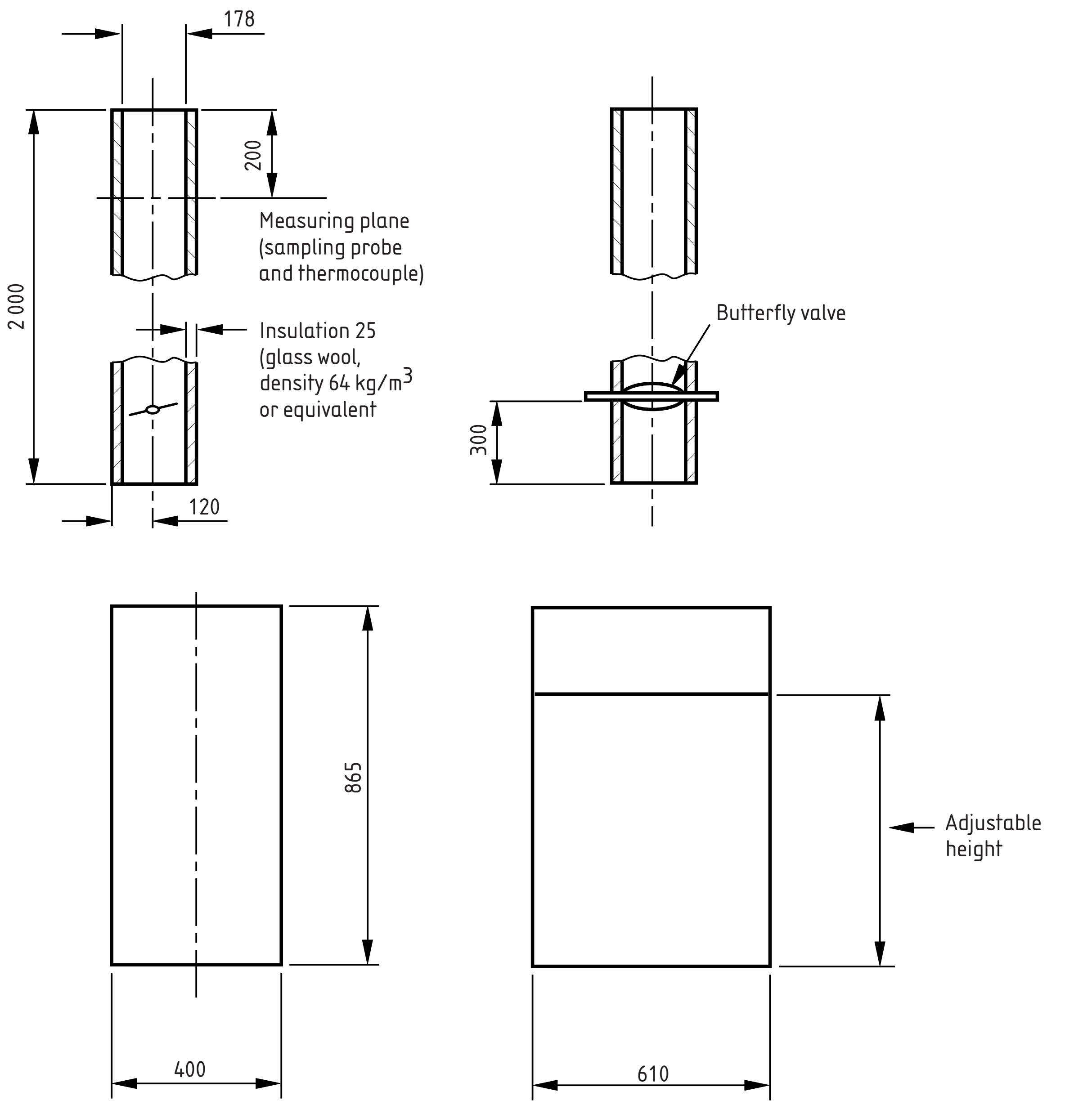
(b) Inset live fuel effect gas fire



(c) Decorative fuel effect gas fire

Figure 1 — Examples of fuel effect appliances

Dimensions in millimetres



a) Side view

b) Front view

Material: Steel (preferably stainless)

NOTE Height = Opening height specified by manufacturer

Figure 2 — Efficiency test rig

Dimensions in millimetres

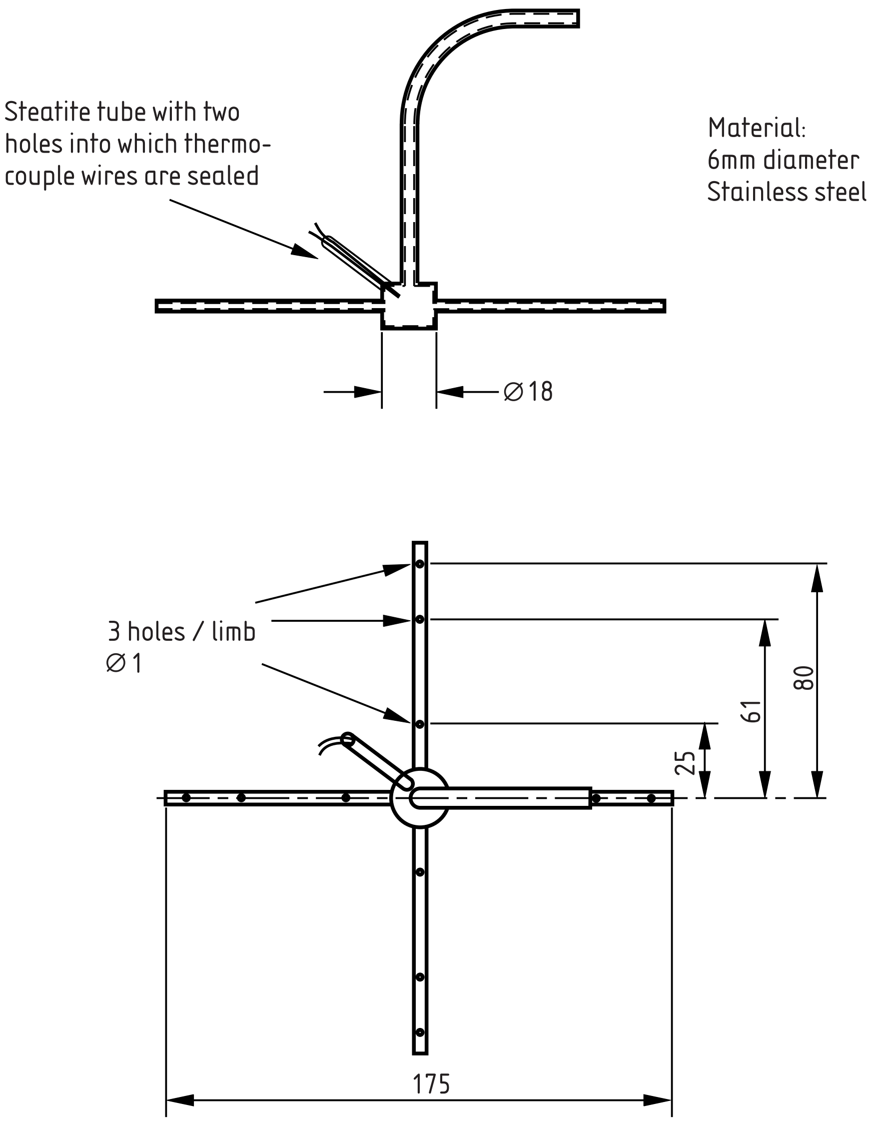


Figure 3 — Sampling probe for the products of combustion and their temperature measurements

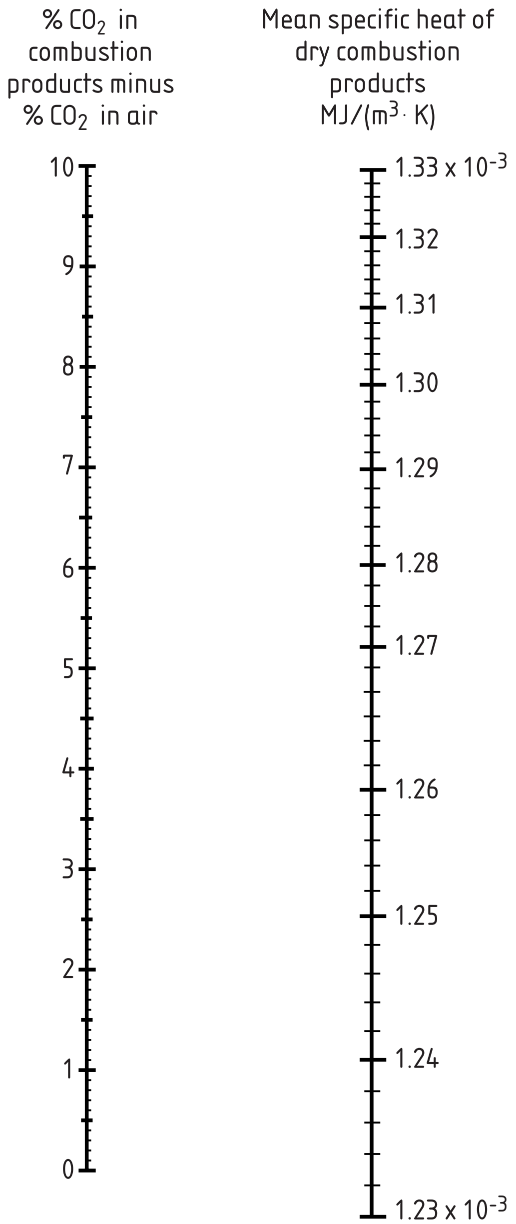


Figure 4 — Mean specific heat of dry products of combustion

Table 1 — Characteristics of the test gases (dry gas, 15 ºC, 1 013.25 bar)

Gas group	Test gases	Designation	Composition by volume	W_i MJ/m³	H_i MJ/m³	W_s MJ/m³	H_s MJ/m³	*d*
Gases of the second family								
Group H	Reference gas	G 20	CH_4 = 100	45.67	34.02	50.72	37.78	0.555
	Incomplete combustion gas Sooting limit gas	G 21	CH_4 = 87 C_3H_8 = 13	49.60	41.01	54.76	45.28	0.684
	Light back limit gas	G 222	CH_4 = 77 H_2 = 23	42.87	28.53	47.87	31.86	0.443
	Flame lift limit gas	G 23	CH_4 = 92.5 N_2 = 7.5	41.11	31.46	45.66	34.95	0.586
Gases of the third family								
Group 3P	Reference gas Incomplete combustion gas Sooting and flame lift limit gas	G 31	C_3H_8 = 100	70.69	88.00	76.84	95.65	1.550
	Light back and sooting limit gas	G 32	C_3H_6 = 100	68.14	82.78	72.86	88.52	1.476

NOTE If the pure reference gases G 20 and G 31 specified in Table 1 are used then the values of V_{CO_2} are G 20 = 1.0 and G 31 = 3.0.

Bibliography

Standards publications

BS 7977-1, *Specification for safety and rational use of energy of domestic gas appliances — Part 1: Radiant/convectors.* [3)]

BS EN 509, *Decorative fuel effect gas appliances.*

BS EN 613, *Independent gas-fired convection heaters.*

EN 1266, *Independent gas-fired convection heaters incorporating a fan to assist transportation of combustion air and/or flue gases.*

prEN 13278, *Open fronted gas-fired independent space heaters.*

[3)] In preparation

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