Ventilation of Domestic Natural Gas Appliances

These notes are for information only and should not be used as a substitute for normative documents or manufacturer's instructions. The notes have been carefully checked for errors but RAD Training (Midland) Ltd. accepts no responsibility for any consequences ensuing upon their use or reliance upon information within them.

These notes form part of the domestic ACS natural gas training programme from RAD Training Midlands. They cover the underpinning knowledge requirements for the ventilation of domestic natural gas appliances. An up-to-date version of these notes is available from www.radmidlands.co.uk

Contents

Page	Topic
2	Why is ventilation important?
	Normative documents
	Determining the category of unsafe situation
3	Types of gas appliance
	Flueless appliances
4	Open flue appliances
	Room sealed appliances
5	Ventilation of flueless appliances
6	Examples
7	Ventilation of open flue appliances
	Adventitious air
	Decorative fuel effect (DFE) appliances
8	Examples
9	Ventilation of rooms containing more than one appliance
	Examples
11	Provision of ventilation
13	Appliances in compartments
14	Examples
16	Ventilation taken through adjoining rooms
	Example
17	Heat input, net and gross
	Conversion table for common units of power and gas rate
18	Glossary

Why is ventilation important?

Gas needs a certain amount of oxygen to burn correctly. One cubic metre of gas needs ten cubic metres of air for **complete combustion**.

The most serious effect of under-ventilation is **incomplete combustion**. This is where lack of oxygen causes carbon monoxide (CO) to be produced. CO is an extremely poisonous gas.

Some gas appliances take their combustion air from the room, which must then have a permanent source of fresh air. It is crucial that air vents are the correct size and type.

Normative documents

Manufacturer's instructions must be followed for specific ventilation requirements of appliances.

British Standard 5440-2:2009 gives general information on ventilation requirements for domestic natural gas appliances.

The Gas Industry Unsafe Situations Procedure – Edition 6 details the procedures for dealing with dangerous or potentially dangerous gas installations. It describes three categories of situation: Not to Current Standards (NCS), At Risk (AR), and Immediately Dangerous (ID).

The Building Regulations – Part J (Heat Producing Appliances)

Determining the category of unsafe situation

If ventilation size is less than 90% of what it should be, or if the ventilation provision is defective in any way, the situation must be categorised as **At Risk** under the Gas Industry Unsafe Situations Procedure. If there is more than one fault it may be necessary to upgrade the situation to **Immediately Dangerous**.

Any At Risk gas appliance must be turned off with a warning label attached until the problem can be rectified. The responsible person for the appliance must be informed.

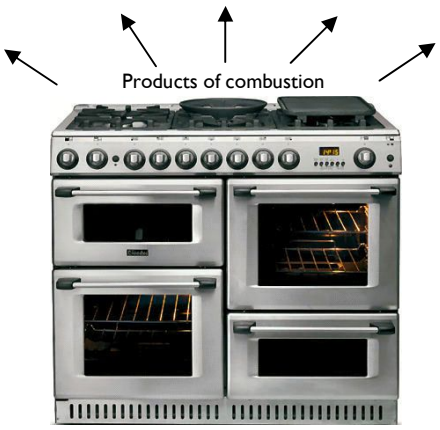
Any Immediately Dangerous gas appliance must be physically disconnected and sealed from the gas supply and labelled. This can only be done with the permission of the responsible person for the property. If permission is not given the gas engineer should refer the matter to the Gas Emergency Service Provider, National Grid, which has rights of entry and the authority to turn off the gas supply to premises containing dangerous gas installations.

Types of gas appliance

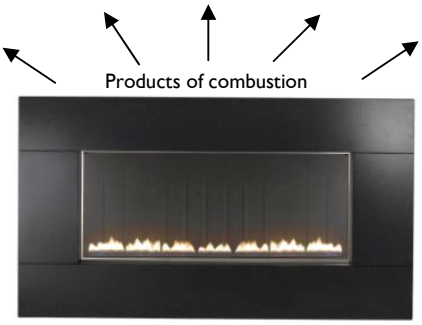
In terms of how they take in air for combustion there are three types of gas appliance:

- flueless
- open flue
- room sealed

Flueless appliances have no chimney or flue. The appliance uses air from the room and releases its products of combustion into the room. This makes these appliances the most potentially dangerous of all.



Flueless gas cooker



Flueless gas fire

Ventilation air for flueless appliances must come directly from outside the property, not through adjoining rooms.

Flueless appliances cannot be installed in bathrooms or shower rooms. Flueless cookers cannot be installed in bedrooms, or in bed-sits under 20 m^3.

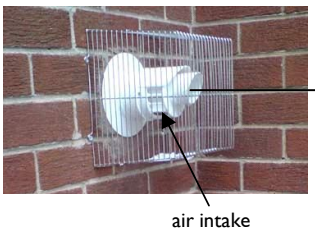
Restrictions of room size apply to most flueless appliances.

Open flue appliances take their combustion air from the room and remove their products of combustion to outside through a chimney or flue. This causes depressurisation of the room which helps draw new air in through vents, etc.

Open flue gas fire

Open flue appliances cannot be installed in bathrooms or shower rooms. Open flue appliances can be installed in bedrooms provided they are of heat input no greater than 12.6 kW net and they have a device that will automatically shut down the appliance in the event of a dangerous build-up of products of combustion in the room.

Room sealed appliances take combustion air from outside and release their products of combustion outside, i.e. their products of combustion are completely sealed from the room in which they are installed. This makes these appliances the safest of the three categories. It also means that the room does not need to be ventilated.



Room sealed boiler and flue terminal

Room sealed appliances may be installed in any room (subject to electrical regulations in bathrooms and shower rooms).

Ventilation of flueless appliances

Flueless appliances use up room air without helping to draw in new air, so room size is important and must be known to determine the ventilation requirements.

The following chart is a simplified version of the one in BS 5440-2:2009.

Appliance type	Maximum allowable heat input	Room volume m^3	Permanent air vent size cm^2	Openable window or equivalent needed?
Cooker, grill, or hotplate	n/a	less than 5	100	YES
		5 to 10	0 if there is a door to outside, 50 if not	
		more than 10	none	
Water heater	11 kW	less than 5	installation not permitted	YES
		5 to 10	100	
		>10 to 20	50	
		more than 20	none	
Fire / space heater in a habitable room	45 watt per m^3	must be at least the heat input kW of appliance divided by 0.045	If 2.7 kW or under: 100 If over 2.7 kW: (heat input – 2.7) x 55 + 100	YES
Fire / space heater in a hallway, landing etc.	90 watt per m^3	must be at least the heat input kW of appliance divided by 0.09	If 5.4 kW or under: 100 If over 5.4 kW: (heat input – 5.4) x 27.5 + 100	YES

Ventilation chart for flueless appliances

The **maximum allowable heat input** column gives details of restrictions for the different types of flueless appliance. For example, flueless water heaters above 11 kW cannot be installed in the UK.

Examples

1. A kitchen of 12 m^3 containing a flueless water heater:

From the chart, a 50 cm^2 permanent vent and an openable window are required.

2. A room of 9 m^3 without a door to outside containing a flueless cooker:

From the chart, a 50 cm^2 permanent vent and an openable window are required.

3. A flueless gas fire of 2.9 kW in a living room of 36 m^3:

Step 1: determine whether the room size is acceptable.

From the chart, room size must be at least the kW of the appliance ÷ 0.045

2.9 kW ÷ 0.045 = 64.4 m^3 required. The room is too small for the appliance and must be treated as an 'At Risk' situation.

4. A flueless space heater of 3.1 kW in a living room of 70 m^3:

Step 1: determine whether the room size is acceptable:

From the chart, room size must be at least the kW of the appliance ÷ 0.045

3.1 ÷ 0.045 = 68.9 m^3 required. The room is big enough for the appliance.

Step 2: calculate the ventilation requirements:

From the chart:

The fire is over 2.7 kW, so the calculation is:

(heat input – 2.7) x 55 + 100
= (3.1 – 2.7) x 55 + 100
= (0.4) x 55 + 100
= 22 + 100
= 122 cm^2 plus an openable window is required.

5. A flueless water heater of 12 kW in a kitchen of 40 m^3:

From the table, the water heater is over the limit of 11 kW and is therefore not permitted. This must be treated as an 'At Risk' situation.

Ventilation of open flue appliances

Determining ventilation is simpler for open flue appliances than for flueless appliances because the only information needed is the **heat input** of the gas appliance in kilowatt (kW).

Ventilation requirement (cm^2) = 5 x heat input (kW)

Adventitious air

Some air may be provided naturally through gaps around openable windows and doors and through floorboards. This is called **adventitious** ventilation. Double glazing and draught-proofing has reduced this source of air in modern and renovated properties and it is currently down to the judgement of the heating engineer to decide whether adventitious air is available or not.

If adventitious air is available the total ventilation requirement of a room (for open flue appliances only) may be reduced by 35 cm^2. This is the ventilation required for 7 kW of heat input.

Decorative fuel effect (DFE) appliances

Most 'decorative fuel effect' (DFE) gas fires need 100 cm^2 ventilation. This figure already has adventitious air taken into account so it cannot be reduced.

These are very low efficiency (~25%) appliances that are more for visual appeal than for heating. Most of their heat is lost up the chimney.

DFEs differ from other gas appliances in other ways such as the types of chimney in which they may be fitted. Manufacturer's instructions must be followed.

Decorative fuel effect (DFE) 'basket' fire

Examples

1. A living room in a newly built house containing an open flue gas fire of heat input 6.5 kW:

6.5 x 5 = 32.5 cm^2 of permanent ventilation is required.

No allowance for adventitious air can be given because newly built houses are constructed to a high level of draughtproofing.

2. A kitchen in an unrenovated house built in 1989 containing an open flue boiler of heat input 26 kW:

26 x 5 = 130 cm^2

Since no renovation has been performed on the house adventitious allowance may be deducted:

130 – 35 = 95 cm^2 of permanent ventilation is required.

3. A room in an unrenovated house built in 1983 containing a DFE:

DFEs require 100 cm^2

100 cm^2 of permanent ventilation is required.

4. A bedroom of an unrenovated 1970s house contains an open flue gas fire of 5.54 kW net:

5.54 x 5 = 27.7 cm^2

Adventitious air is available, given the age of the property. Since the ventilation requirement of the fire is less than 35 cm^2 no purpose provided ventilation is necessary.

Ventilation of rooms containing more than one appliance

This is not simply a case of adding together ventilation requirements of each appliance. Like apples and oranges, some gas appliances are too different to add together. For example, **open flue** appliances help room ventilation while **flueless** appliances do not.

There is also a difference in usage between **space heaters** and **other** gas appliances. Space heaters are appliances designed to heat living spaces, such as gas fires, warm air units and central heating boilers. These may be running for several hours while other appliances (such as cookers and water heaters) are used for shorter periods.

Multi-appliance room ventilation is the largest of either:

- the total ventilation requirement of the **open flue space heaters**, OR:
- the total ventilation requirement of the **flueless space heaters**, OR:
- the largest individual requirement of **any other kind of appliance**

Putting appliances into these three categories is the crucial first step to determining multi-appliance ventilation.

Examples

1. A kitchen of 18 m^3 in an unrenovated 1990s house contains:

a) a flueless water heater of heat input 8.5 kW
b) an open flue boiler of heat input 28 kW
c) an open flue gas fire of heat input 5 kW

Firstly. categorise the appliances:

Appliances b) and c) are both open flue space heaters. Appliance a) is not a space heater so it will come under the 'other' category. Put the categories in a table thus:

Open flue space heaters	Flueless space heaters	Others
b) 28 kW **c) 5 kW** 28 + 5 = 33 kW total 33 x 5 = 165 cm^2 165 – 35 cm^2 adventitious = 130 cm^2	None	**a) flueless water heater** From chart, 50 cm^2 plus an openable window required
TOTAL = 130 cm^2	TOTAL = 0	LARGEST = 50 cm^2

The required ventilation for the room is the largest of these three figures, i.e. 130 cm^2. Note: an openable window is still required because there is a flueless appliance in the room.

2. A kitchen of 20 m^3 in an unrenovated 1950s house contains:

a) **a flueless cooker**
b) **an open flue boiler of heat input 26 kW**
c) **a flueless water heater of heat input 10 kW**
d) **an open flue gas fire of heat input 6 kW**

Appliances b) and d) are both open flue space heaters. Appliances a) and c) are not space heaters and so will come under the 'other' category.

Open flue space heaters	Flueless space heaters	Others
b) 26 kW **d) 6 kW** 26 + 6 = 32 kW total 32 x 5 = 160 cm^2 160 – 35 cm^2 adventitious = 125 cm^2	None	**a) flueless cooker** From the chart, no purpose-provided vent is needed but an openable window is required. **c) flueless water heater** From the chart, a 50 cm^2 vent and an openable window is required.
TOTAL = 125 cm^2	TOTAL = 0	LARGEST = 50 cm^2

The open flue space heater category requirement is the largest at 125 cm^2 so this is the overall room ventilation requirement. Note the openable window is still required.

3. A room of 70 m^3 contains:

a) **a DFE of heat input 5.6 kW**
b) **a flueless gas fire of heat input 2.9 kW**

It is necessary to first check whether the room is big enough for the flueless gas fire. From the chart, the room should be at least 2.9 ÷ 0.045 = 64.4 m^3, which it is.

Open flue space heaters	Flueless space heaters	Others
a) DFE requires 100 cm^2	**b) flueless gas fire** 2.9 – 2.7 = 0.2 0.2 x 55 = 11 11 + 100 = 111 cm^2	None
TOTAL = 100 cm^2	TOTAL = 111 cm^2	LARGEST = 0

The largest category is the flueless space heaters so the room needs 111 cm^2 plus openable window.

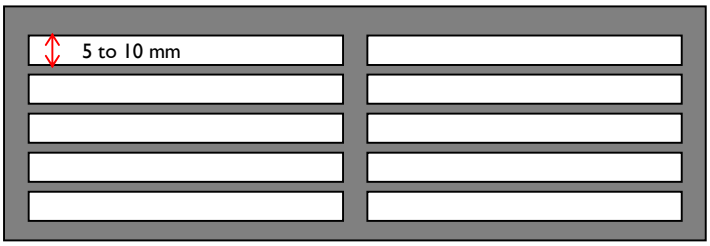
Provision of ventilation

Ventilation for gas appliances must be provided by air vents.

Air vents used for the ventilation of gas appliances must:

- be permanently open.
- not have a mesh or flyscreen; these can be blocked by dust too easily.
- be of rigid construction. Certain types of aluminium vents are not permitted because it is possible for householders to press shut the soft metal openings.

An air vent will be divided into a number of holes:



The smallest side of each hole should be between 5 mm and 10 mm. If it is below 5 mm there is a possibility of blocking. If it is over 10 mm there is the possibility of the entry of vermin.

For example, if each hole in the vent above measures 105 x 6 mm the total **free area** of the vent can be calculated as follows:

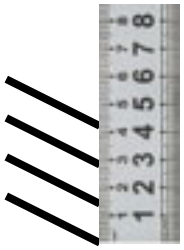
Free area of each opening = 105 x 6 = 630 mm^2
630 x 10 holes = 6300 mm^2

To convert mm^2 to cm^2, divide by 100:

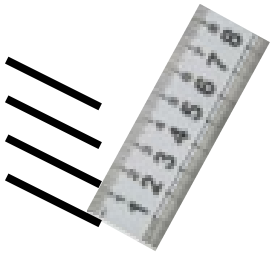
6300 ÷ 100 = **63 cm^2**

If the vent has sloping vanes it is important to measure the internal size, not the external size:

Air vent with sloping vanes

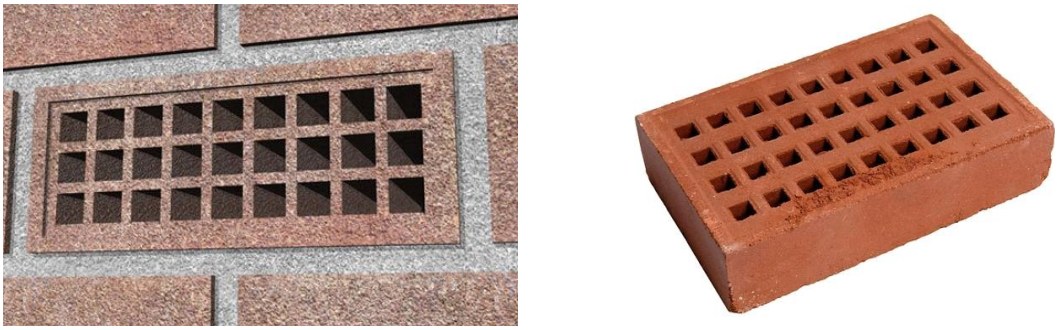


incorrect measurement = 14 mm



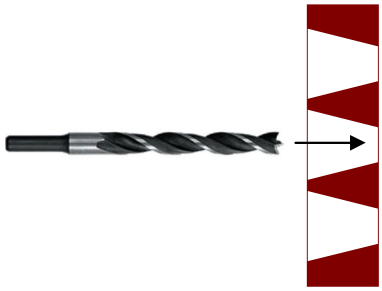
correct measurement = 10 mm

Air bricks are an acceptable form of ventilation but the amount of free air they provide is not great (typically 20 to 40 cm^2).



Air bricks

The visible side of the brick generally has holes which are larger than the side opening into the wall cavity. This causes a difficulty in measuring the free area because it is the smaller, non-visible measurements that must be used. The problem can be solved by inserting a drill bit of known diameter into the hole. Progressively larger bits can be used to find the size.



Warning: do not use a drill to make ventilation holes larger

Using a drill bit to determine the hole size of an air brick

Appliances in compartments

Open flue and room sealed appliances (but not flueless appliances) may be installed in a compartment. A compartment is a purpose-designed enclosure or cupboard used for decorative reasons to hide a gas appliance.

A compartment containing a gas appliance should not be used for any other purpose (e.g. drying linen) unless a specially-designed separate section is provided so there is no possibility of blocking vents or creating a flammable situation.

Compartments containing open flue appliances must be ventilated for combustion air and for cooling air.

Compartments containing older room sealed appliances may need to be ventilated for cooling air. Newer room sealed appliances may run cool enough to not require ventilation. Manufacturer's instructions should be followed.

Compartments must be ventilated at both high and low level. The low level vent allows the entry of cool air. The high level vent allows the removal of warmed air.

Compartment vents at high and low level should communicate with the same space or the same outside wall. If they communicate to different areas there is the possibility of cross-ventilation where unequal air pressures create draughts potentially harmful to the combustion of the appliance.

If manufacturer's instructions are not available the following table may be used to size the air vents:

Compartment ventilation (cm^2 per kW)	Open flue		Room sealed	
	Vents to outside	Vents to room	Vents to outside	Vents to room
high level	5	10	5	10
low level	10	20	5	10

Compartment vent sizes

Ventilation may be ducted into a compartment from a ventilated roof space. Separate ducts should be provided to both high and low level. The cross sectional area of the duct must be at least equal to the area of the vent it serves. A ventilated roof space may be considered as outside air if it is sufficiently ventilated (see BS 5250) but otherwise must be treated as an internal space.

In the case of an open flue appliance in a compartment vented into the room, the room must be ventilated according to the normal requirements of the appliance.

Compartments may not be used to house open flue appliances in a bathroom or shower room. Compartment air vents may not communicate with a bathroom or shower room.

There is no allowance for adventitious air in compartments.

Examples

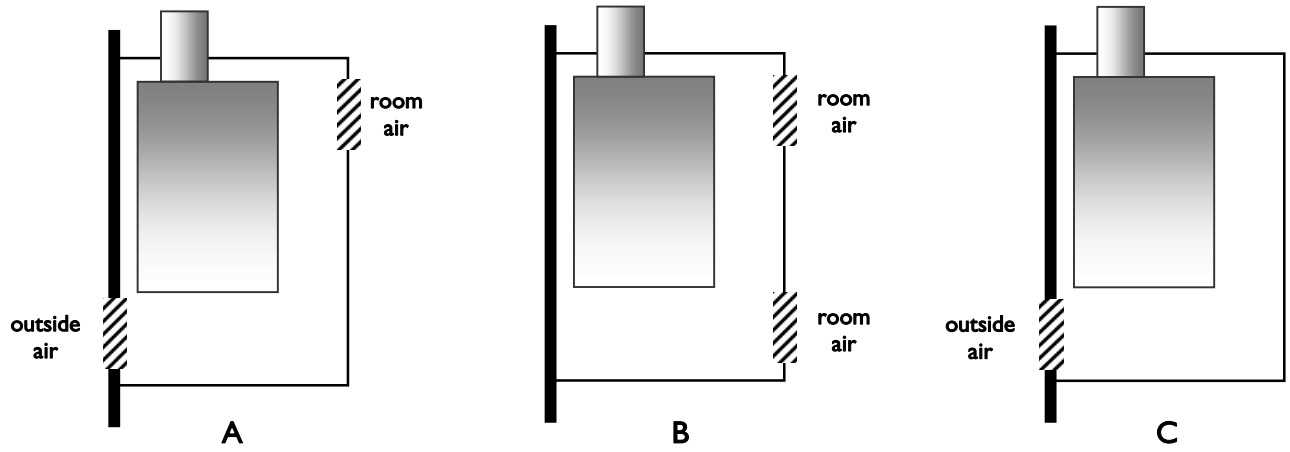
1. A room sealed boiler of 28 kW heat input is installed in a compartment with air vents communicating directly to outside air:

From the table, the compartment requires 28 x 5 = 140 cm^2 at high level and the same at low level.

2. An open flue water heater of 18 kW heat input is installed in a compartment with air vents communicating with a kitchen:

From the table, the compartment requires 18 x 10 = 180 cm^2 at high level and 18 x 20 = 360 cm^2 at low level.

3. Are the following compartment installations acceptable or not?

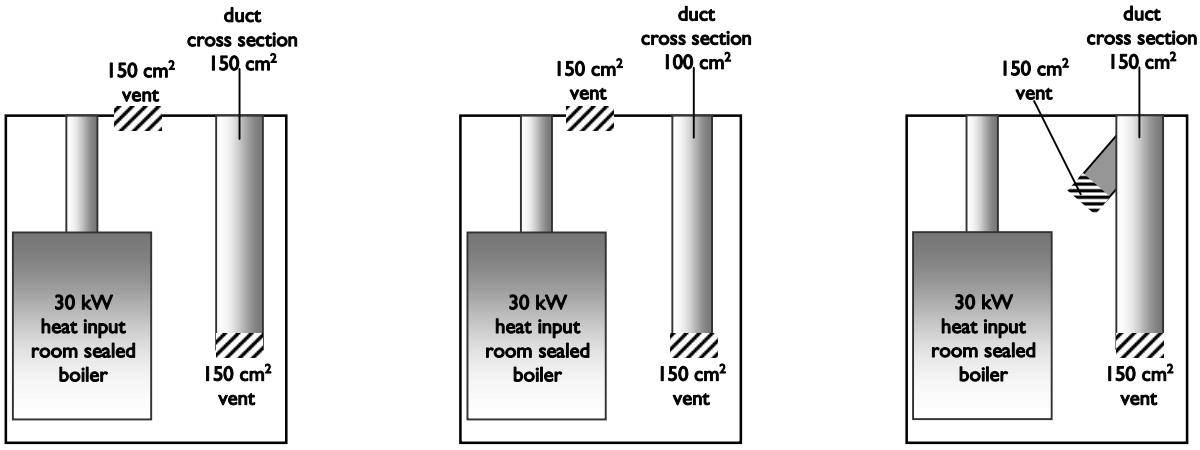


Installation A – unacceptable: the two vents are communicating with different spaces.

Installation B – acceptable

Installation C – unacceptable: no high level ventilation is provided.

4. Are the following compartment installations in which ventilation is ducted from a ventilated roof space into the compartment acceptable or not?



A B C

A – correct.

B – incorrect. Cross sectional area of duct is too small for the vent size.

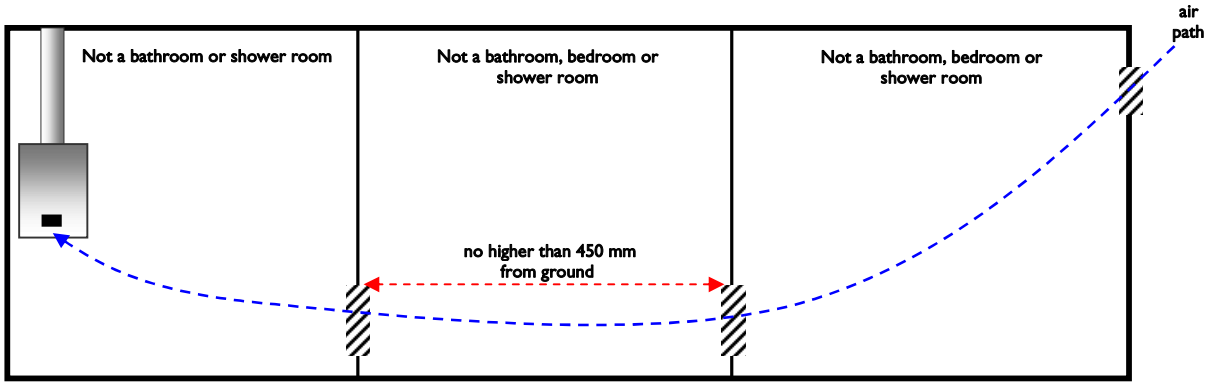
C – incorrect. Vents cannot share a duct.

Ventilation taken through adjoining rooms

If there is no position to put an air vent direct to outside, ventilation may be taken through rooms using a series of air vents before reaching outside air.

Notes:

- This is for open flue ventilation only. Flueless appliances must be ventilated or ducted directly to outside.
- If the ventilation is taken through more than one internal wall the internal air vents should be 50% bigger than the external vent (which is sized normally).
- The connecting rooms cannot be a bathroom, shower room or bedroom.
- Internal air vents should be positioned at low level, no higher than 450 mm from the floor. This is to slow the passage of smoke and poisonous gases in the event of a fire.



Vents in series

Example

1. An open flue water heater of heat input 15 kW is installed in the kitchen of a house built in 1983. Ventilation is to be taken through two adjoining rooms, neither of which is a bathroom or shower room. Calculate the size of the external vent and the two internal vents, stating any positional requirements.

External vent: 15 kW x 5 = 75 cm^2. Because of the age of the house, adventitious air will be assumed: 75 – 35 = 40 cm^2

Internal vents: both internal vents will be 40 cm^2 + 50% = 60 cm^2

The internal vents should be positioned no higher than 450 mm from the ground.

Heat input, net and gross

The heat input of modern gas appliances is usually given in kilowatt (kW).

There are two types of kilowatt: **net** and **gross**. This is because during the 1980s there was a change in the way that the energy content of gas was calculated.

All of the ventilation formulae used in these notes work with **net** kilowatt. The heat input of some older appliances will be given by manufacturer's instructions in gross kilowatt. Gross kW can be converted to net as follows:

net kW = gross kW ÷ 1.1

For example, an open flue boiler of 21 kW gross would be 21 ÷ 1.1 = 19.09 kW net.

If it is unknown whether heat input is being given in kW net or kW gross, assume net.

Other units of power include BTU / h (British thermal units per hour), m^3/h (cubic metres of gas per hour), and ft^3/h (cubic feet of gas per hour). These can be converted into kW net using the following chart:

Conversion table for units of power		Convert to:				
		m^3/h	ft^3/h	BTU/h	kW gross	kW net
Convert from:	m^3/h		x 35.35	x 36764	x 10.77	x 9.80
	ft^3/h	÷ 35.35		x 1040	÷ 3.28	÷ 3.61
	BTU/h	÷ 36764	÷ 1040		÷ 3412	÷ 3753
	kW gross	÷ 10.77	x 3.28	x 3412		÷ 1.1
	kW net	÷ 9.80	x 3.61	x 3753	x 1.1	

Conversion table for common units of power and gas rate

For example, a boiler of heat input 42000 BTU/h would be 42000 ÷ 3753 = 11.2 kW net.

Glossary

Adventitious air	ventilation entering a room naturally
Air vent	a purpose-made opening to allow fresh air into a room
Carbon monoxide	a highly poisonous, invisible, odourless gas
Carbon dioxide	a waste product of the complete combustion of natural gas
CO	chemical formula for carbon monoxide
CO_2	chemical formula for carbon dioxide
Complete combustion	gas burned in enough oxygen to produce no carbon monoxide
Flue	a chimney of a gas appliance
Free area	a measure of the amount of air provided by holes in an air vent
Heat input	the power of an appliance, usually measured in kilowatt (kW)
Incomplete combustion	gas burned in too little oxygen, producing carbon monoxide
Natural gas	the mains gas used in the UK; methane
Products of combustion	waste gases produced by a gas appliance
Space heater	a gas appliance designed to heat rooms for comfort
Vent	see *Air vent*
Ventilation	the provision of air for a gas appliance