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Amendments to SAP's treatment of the heat loss from chimneys and flues

Issue 1.0

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DOCUMENT REVISION LOG

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1. INTRODUCTION

The value of 40m^3/hr attributed to the average air-flow in chimneys in SAP is based on limited information. BRE has undertaken a project to improve the accuracy of this value by monitoring in real dwellings (1). The results from this and from previous work have implications for other ventilation in SAP.

The present value in SAP for chimneys was based on work by BRE and Dickson. BRE Report BR359 (2) describes airtightness tests showing an airflow of 400m^3/hr at 50Pa, with other reports supporting this figure. Dividing by 20 suggests a flow rate of around 20m^3/hr at normal air pressures, but it is uncertain whether this 'rule of thumb' is robust when applied to flues.

Chimney Vertical duct for combustion gases diameter 200mm or more	40 m^3/hr
Flue Vertical duct with diameter less than 200mm Chimney for solid fuel appliance with controlled air supply Chimney fitted with a damper Open flue gas fire with flue products outlet sealed to the chimney Blocked fireplace with ventilator area less than 30,000 mm^2	20 m^3/hr
Intermittent extract fan Typically kitchen or bathroom, also cooker hoods and other independent extract fans	10 m^3/hr
Passive stack vent Extract grilles connected to ridge terminals by ducts	10 m^3/hr
Flueless gas fire	40 m^3/hr
Balanced flue	zero

Table 1. Ventilation rates attributed in SAP and BREDEM

Dickson (3) describes the results of tracer gas decay methods in a low energy design semi with MVHR. The open fireplace increased the air flow rate by about 50m^3/hr, or 75m^3/hr with the floor vent (for combustion air) open. Wind speeds were between 1 and 6 m/s, lower than the average of 5m/s for most of this country. External temperatures were between 11 and 21ºC, milder than a heating season average of 6ºC. These two factors and the airtightness of the house, 0.15 to 0.20 ac/h, may therefore underestimate the flow rate for existing dwellings in more typical weather conditions.

2. SUMMARY OF EVIDENCE

A BRE project undertaken in 2015 aimed to measure chimney airflow rates, with fire unlit, in typical occupied dwellings heated by other means. Direct monitoring of volume airflow is difficult so measurement of the driving pressure, the difference between the top and bottom of the chimney, was developed. Following this, a two-step methodology was used.

For dwellings with a chimney and open fireplace:

(a) The pressure difference[1] between the top and bottom of the chimney is monitored over a period of seven days. No fires are lit and the dwelling is occupied as normal.

(b) Two airtightness tests[1] are carried out, firstly with, and then without the chimney fireplace opening sealed, over a range of pressure differences. The measured airflow rates at the pressure differences applied are then used to derive an equation between these two variables.

The dwellings were selected from an invitation to BRE employees or their family/friends. The project involves physical measurements so this should not result in any bias. The chimneys were swept before monitoring due to the risk of disturbed debris and soot causing damage in the room, although it would have been preferable to monitor them 'as found'. To take account of this, the amount of debris swept out in each dwelling was assessed.

The following factors which may significantly affect the airflow were recorded.
Dwelling specific factors, constant over the period of monitoring:

[1] Testing confirmed that the equipment used was correctly calibrated.

- ‘airtightness’ of the dwelling as measured by a standard air pressurisation test
- length of flue and number of storeys
- chimney throat, damper, flue area, device on chimney pot

Common factors which are not constant over the period of monitoring in each dwelling:

- temperature internally and externally (the temperature difference)
- wind speed (from local weather data)

Other factors, such as opening of windows, doors and vents will also cause some variation. Since the results are over a number of days and dwellings, this will become a contribution to the experimental variation, and since these factors will be representative of dwellings in normal use, it is not thought that this will bias the average result.

20 dwellings were monitored from late February to early April 2015, a period with external temperatures below 10 to 15°C much of the time. During later analysis, problems were encountered with some of the data from three properties, so that it has been possible to successfully calculate full results for 17 properties, Figure 1.

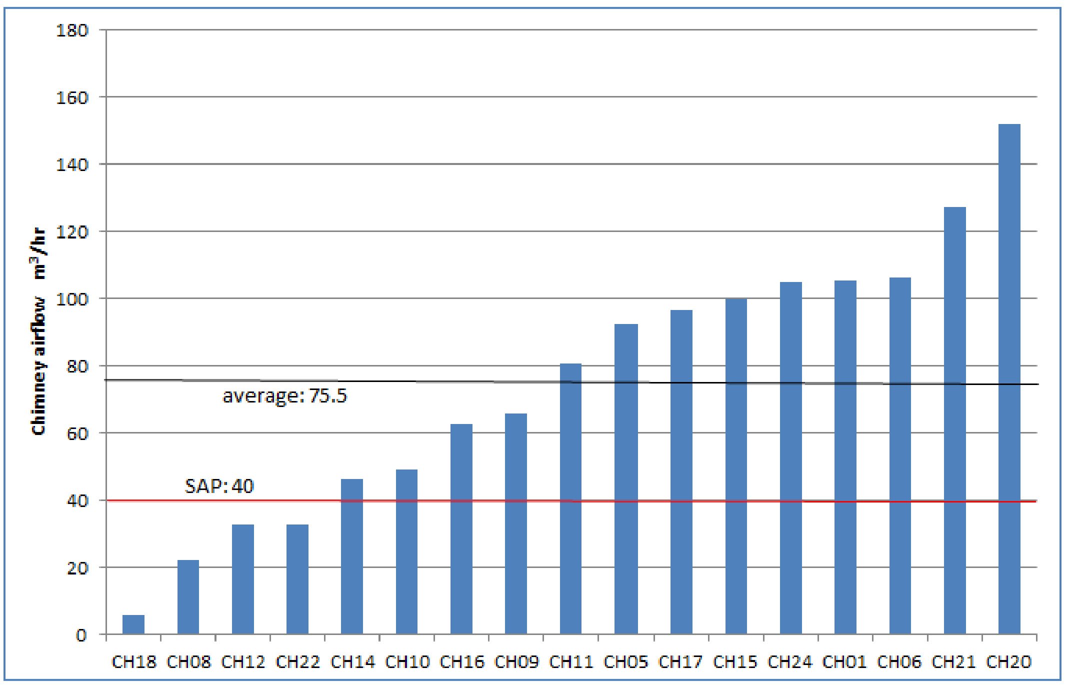

Figure 1. Calculated seven day average chimney airflows for 17 dwellings.

The results indicate seven day average chimney airflows of between 5 and 150 m^3/hr.

- The average of the values is 75.5m^3/hr.

- The standard error is 10m^3/hr, so based on the variability of these results this indicates a 95% probability of the true mean being between 75.5 $\pm$ 20 m^3/hr.

Analysis for CH08 and CH10 suggests that these may be less reliable results. With these two cases removed, this still gives chimney airflows of between 5 and 150 m^3/hr.

- The average of the values is 80.8m^3/hr.
- The standard error is 10.5m^3/hr, so based on the variability of these results this indicates a 95% probability of the true mean being between 80.8 $\pm$ 21 m^3/hr.

Items such as cowls, dampers, and solid floors were recorded, but none related strongly to the airflow measured, except perhaps for the dwellings with solid floors which have generally lower airflows; this may restrict the air available for the chimney.

The temperature and windspeed data from local weather stations during the monitoring were 6.8 to 8.0^{o}C and 4.3 to 5.0m/s. When compared with 20 year averages of 7.6^{o}C and 5m/s, this indicates conditions that are representative of the UK average. Compared to the air permeability of 384 dwellings (average 11.5m^3/hr/m^2) reported by Stephens (2), the 17 dwellings monitored (average 7.5m^3/hr/m^2) are mostly in the lower half of the distribution. However no correlation was found between airtightness and chimney airflows of the 17 dwellings, so this indicates that this is not a major factor.
Assessment of the debris swept from each chimney was recorded as blocking the flue airflow ‘minimally’, ‘significantly’ or ‘substantially’. All except two chimneys were assessed as ‘minimally’ blocking the airflow.

It is clear from Figure 1 that there is a large variation in the results. A wide variety of factors will be causing this, including the following.

- The airtightness of the room allowing air into and up the chimney; both the leakiness of the dwelling envelope and the opening of the internal door(s) to the rest of the house and the opening of windows to the outside,
- The wind speed and direction and the effect of the roof configuration affecting the airflow around and over the top of the chimney, creating changes in pressure,
- The shape of the chimney at the fireplace opening and on its way up to the roof.

Examining graphs of the pressure difference shows variation from hour to hour over the seven days, presumably as the wind changes direction and speed and as doors and windows are opened. (One of the participants could identify a brief but clear change in pressure at the time his wife normally left the house in the morning).

The data was also analysed to investigate correlation with different variables, as this might be used to reduce the variability of the results. A clear relationship between windspeed and chimney airflow was noted, though the correlation coefficient was only 0.47 and other factors are clearly having an effect. The temperature difference creating a ‘stack effect’ was analysed, and no correlation was found overall, however if small time periods of an hour or two during low wind were isolated, a strong correlation could be detected. It is thought that these represented periods when the dwelling was in a stable state so that the effect could be detected. The pressure difference can be seen to quickly drop or rise at particular times, maybe due to a door or window being opened or closed. It may be possible with further analysis of the data and some theoretical analysis to relate airflow to the temperature difference, and use this in SAP.

As part of work undertaken by George Henderson in 2006, an Excel based model of air flow through chimneys was developed by Gastec at CRE Ltd (see Appendix). This calculates the pressure difference up the chimney from the difference in density between the air/gases in the chimney and the density of the external air. The pressure drop along the length of the chimney due to flow resistance is also calculated, using an estimate of the area of openings through which air enters the room with the chimney, together with other factors characterised in standard fluid dynamics such as a friction factor and discharge coefficients. The calculated flow rate is then adjusted until the pressure difference matches the pressure drop arising from the flow resistance. This model gives the average annual flow rates in Table 2.

Some reasonable estimates have been made in this model, and the results the model gives for chimneys are consistent with the values of 75 to 80m^3/hr from the BRE measurements. This gives support to the soundness of the model, and suggests that the other results in the table may be used as a valuable source to inform revisions to other ventilation rates in SAP.

The specified heating in rows 1 to 10 of Table 2 were assumed to be secondary heating systems with 500 hours ‘periodic’ firing per year. The wood chip boiler in row 11 was assumed to be a primary heating source and the firing hours were raised to 1500hrs.

		No fire	Periodic firing	Full firing
1	Open chimney (12"x4") - 10 kW	102	111	245
2	Open chimney (12"x4") - 5 kW	102	109	207
3	Open chimney DGF 10 kW	94	101	211
4	Open chimney DGF 6.9 kW	66	70	132
5	ILFE 10 kW (9000mm2)	40	43	106
6	ILFE 6.9 kW (9000mm2)	38	42	93
7	Radiant gas fire 125mm flue 10 kW	28	32	83
8	ILFE 125mm flue 6.9 kW	28	31	82
9	Wood stove into unlined chimney (10kW)	10	12	58
10	Wood stove into unlined chimney (5kW)	10	11	29
11	Wood chip boiler 15 kW, 80% efficiency, into 125 mm flue (1500 hrs firing)	10	22	82

Table 2. Average annual flow rate from Excel based model m^3/hour

DGF – decorative gas fire

In addition, George Henderson's work points out that Building Regulations ADF Table 5.2b gives Passive Stack Ventilation internal duct diameters required to give specified extract rates. 125mm diameter is given for a kitchen to achieve 47m^3/hour and for a bathroom or utility room to achieve 29m^3/hour. A Passive Stack Ventilator is a vertical pipe and essentially similar to a chimney flue. From these values the flow rate for a typical chimney flue (which has a cross section area perhaps 4 to 8 times larger) would be expected to be higher than the present SAP value of 40m^3/hr.

3. PROPOSED CHANGES TO SAP

Chimney flue

It is proposed that the chimney flow rate be increased, based on the following evidence

- The present value of 40m^3/hr is based on two pieces of work, one a rule of thumb which is uncertain, the other tracer gas decay tests giving results of 50 to 75m^3/hr which are probably underestimates due to mild weather conditions and the airtightness of the low energy design house.
- Work by George Henderson identified inconsistencies between SAP and AD Part F, suggesting a flow rate around 118m^3/hr. This was supported by an Excel based model giving a value of 70 to 110m$^{3/}$/hr (Table 5, rows 1 to 4).
- The monitoring undertaken in 17 typical existing dwellings during typical heating period weather conditions gave an average of 75 to 80m^3/hr. Chimneys were swept first which might cause this average to be a slight overestimate, however few were significantly blocked. The airtightness of the dwellings were mostly in the lower half of the distribution of a larger dataset of 384 dwellings and this may mean the average is a slight underestimate, although airtightness was not found to be a significant factor. Overall it is thought that neither of these factors significantly affects the average results.

A flow rate of 80m^3/hr is therefore proposed, while retaining the present definition.

The issue of temporarily blocking the chimney with a commercial product or newspaper should be kept in mind. This cannot be considered for purposes such as an energy rating which must only take account of fixed measures. It may be noted that of the 20 open fireplaces in the BRE project, 15 were not temporarily blocked when not in use, moreover, of these, 8 were never used for a fire.

Flues (diameter less than 200mm)

Rows 5 to 8 of Table 2 give values between 28 and 43m^3/hr. These sorts of flue have a heating appliance at the bottom which introduce resistance to air flow.

A flow rate of 35m^3/hr is therefore proposed for an appliance flue.

Rows 9, 10 of Table 2 give values between 10 and 12m^3/hr for a wood burning stove. A similar value might be expected for a solid fuel closed stove.

A flow rate of 10m^3/hr is therefore proposed for wood or solid fuel stove flues.

Row 11 of Table 2 gives a value of 22m^3/hr for a wood chip boiler, assuming this is used as a primary heating source. A similar value might be expected for a solid fuel boiler.
A flow rate of 20m^3/hr is therefore proposed for wood or solid fuel boiler flues.

From the information on householders temporarily blocking a chimney above, the presence of a damper may not mean that it is pulled across to reduce the airflow.
It is therefore proposed that 'Chimney fitted with a damper' is taken out of this category and included as a full chimney flue with a flow of 80m^3/hr.

At present a permanently blocked chimney with ventilation not exceeding 30,000mm^2 is given a value of 20 m^3/hr.
Retaining a flow rate of 20 m^3/hr is proposed for a blocked chimney.

Intermittent extract fans

The present SAP value of 10 m^3/hr for an intermittent extract fan may be considered in terms of the extraction rate for a typical fan airflow of 80m^3/hr and an average running time of 7.5 minutes per hour. Increasing this would give an excessive running time.
Retaining a flow rate of 10m^3/hr is proposed for an intermittent extract fan.

Passive Stack Vent

AD Part F gives a duct diameter of 125mm (cross sectional area 12,000mm^2) for rooms to achieve between 22 and 47m^3/hr (Table 2). However, PSV's are humidity-controlled therefore a lower average flow is appropriate.
Retaining a flow rate of 10m^3/hr is proposed for a Passive Stack Vent.

Flueless gas fire

The value in SAP relates to the air change rate needed to remove combustion products..
Retaining a flow rate of 40m^3/hr is proposed for a flueless gas fire.

4. IMPACT OF PROPOSED CHANGES

EHS (English Housing Survey) data indicates that the number of open fireplaces which are not permanently blocked and not in regular use as the main heating system is around 9 million open fireplaces in 6.75 million dwellings (this is just under 30% of dwellings in England).

An example SAP calculation may be carried out for gas central heating of 80% efficiency in a typical semi-detached. This indicates that the present ventilation rate for a chimney of 40m3/hr results in the use of around 600 kWh/yr of fuel, compared to the same dwelling with no chimney. The proposed doubling of the chimney ventilation rate to $80m^3$/hr in a leaky dwelling approximately doubles this to 1200 kWh/yr as one might anticipate. However, for airtight dwellings, occupant ventilation (opening windows) is assumed to increase if ventilation is reduced below a certain level, and as a result the fuel requirement due to doubling the chimney ventilation rate is increased by somewhat less than double. This effect increases with the airtightness of the dwelling. Another way of assessing the impact is by its effect on SAP rating. Doubling of the chimney ventilation rate will typically result in a worsening of the SAP rating by 1 or 2 points per chimney.

5. CONCLUSION

BRE has undertaken a project which measured chimney airflow rates in occupied dwellings typical of the existing housing stock. The results are consistent with the results of other work, in particular that by George Henderson which included an Excel based model developed by Gastec at CRE Ltd of flow rates in flues.

This evidence has been used to propose the following new ventilation values in SAP.

Chimney Vertical duct for combustion gases diameter 200mm or more including decorative gas fires and chimneys with a damper	80 m^3/hr
Flue[1] **(1)** Open flue gas fire with flue products outlet sealed to the chimney including radiant gas fires and ILFE	35 m^3/hr
Flue[1] **(2)** Flue for wood or solid fuel boiler	20 m^3/hr
Flue[1] **(3)** Flue for wood or solid fuel stove/appliance with controlled air supply	10 m^3/hr
Blocked chimney Blocked chimney with ventilator area less than 30,000 mm^2	20 m^3/hr
Intermittent extract fan Kitchen, bathroom, cooker hoods and other independent extract fans	10 m^3/hr
Passive stack vent Extract grilles connected to ridge terminals by ducts, humidity control	10 m^3/hr
Flueless gas fire	40 m^3/hr
Balanced flue	zero

Table 3. Proposed ventilation values

[1]Vertical duct with diameter less than 200mm

Alternatively the present 20m3/hr for Flue (1), (2), (3) could be retained

6. REFERENCES

(1) Iles P. Chimneys – monitoring airflows. DECC Client Report. July 2015.

(2) Stephen R, K. Airtightness in UK dwellings: BREs test results and their significance. BRE report BR359.

(3) Dickson, D.J. Infiltration rates in a low energy house with a fireplace. Building Research and Practice, Number 4, 1988.

APPENDIX: Extract from George Henderson/Gastec at CRE report.

Calculations of flow rates in chimneys

Gastec at CRE Ltd (GaC) have developed an Excel spreadsheet model of a chimney for this project. Pressure difference is calculated from the difference in density between the air and/or flue gases in the chimney and the ambient air, according to the expression

$$\Delta P = (\rho_a - \rho_f).g.h \qquad (2)$$

where ρ_a is the density of the ambient outdoor air, ρ_f is density of air or air/gas mixture within the flue, g is the acceleration due to gravity and h is the height of the chimney. When firing is taking place, the energy imparted to the flue is used to calculate the flue temperature along with the temperature of the air inside the building.

Resistance to flow is calculated from consideration of the path taken by the combustion air into the room in which the chimney is located and through the appliance, and of the flue gases through the chimney itself.

The pressure drop due to the flow of air into the room from which the chimney takes its ventilation is calculated according to the expression

$$\Delta P = \tfrac{1}{2}\rho_a v^2/C_d^2 \qquad (3)$$

where v is the mean velocity through the ventilator and C_d its discharge coefficient, taken to be 0.61. Allowance needs to be made for infiltration and other background ventilation in the room. Appendix A of ADF assumes an infiltration rate of 0.15 ach (or 0.2 for single storey house), or around 30 m^3/hour for a whole dwelling. Using equation (1) it may be observed that this equates to around 21,000 mm^2 of openings, taking account of the fact that the result must be doubled to allow for both inward and outward paths. If this area is distributed pro-rata with floor area, it may be assumed that around a quarter is in the living area, which contains the fireplace. It should also be noted that ADF specifies undercuts of at least 7,600 mm^2 on all doors to ensure good transfer of air throughout the dwelling. Taking that into consideration, it seems reasonable to assume an equivalent area of around 10,000 mm^2 in the room with the fireplace before any additional ventilator area, as required by Part J of the Building Regulations, is fitted. This is included in the spreadsheet as the “infiltration allowance”. It may be noted that an allowance for infiltration is also made when specifying the ventilator area for some types of appliance in Approved Document J (ADJ). For example, Diagram 3.2 of ADJ shows a requirement for a gas appliance in a room only if the output exceeds 7kW.

Equation 3 is also used to calculate the pressure through the appliance and at the top of the chimney. If it can be assumed that restriction in the appliance is similar to that produced by an orifice, then a C_d of 0.61 should be applied in that case also. The chimney top, however, may be an open nozzle, in which case C_d should be close to 1.

The pressure drop through the length of the chimney is calculated using the Darcy equation

$$\Delta P = \lambda(h/d)\tfrac{1}{2}\rho_f v^2 \qquad (4)$$

where λ is the friction factor, and *h* and *d* are the length and diameter of the chimney respectively. The friction factor, λ, depends upon the Reynolds number, *Re*, and the relative roughness of the chimney wall. It is often obtained by reference to the Moody chart, as described in Section 4.3 of CIBSE Guide C. For laminar flow ($Re < 3000$) it may be calculated using the simple expression

$$\lambda = 64/Re \qquad (5)$$

but for turbulent flow, accurate calculation requires iteration using the Colebrook-White equation. There are also a number of equations developed to give reasonable approximations without the use of iteration; the one used in this case was taken from Coulson and Richardson, Chemical Engineering, Volume 3 (1978).

The calculated flow rate is adjusted until the pressure difference matches that arising from the flow resistance, using the “solver” tool in Excel.

The spreadsheet described above was used to calculate airflows for a number of appliances under both cold and firing conditions, as shown in Table 3 below. The fifth column shows the average flow rate over a year based on the assumption that the appliance is firing at the equivalent of full rate for 500 hours, for cases 1 to 10, which are assumed to be secondary heating systems. For case 11, which is assumed to be the primary heating source, the firing hours are raised to 1500.

Table 3: Air flow rates calculated for various appliances

		No fire	Full firing	Average flow based on 500 hours firing	Room pressure drop when full firing
		m3/hour			Pa
1	Open chimney (12"x4") - 10 kW	102	245	111	11
2	Open chimney (12"x4") - 5 kW	102	207	109	8
3	Open chimney DGF 6.9 kW	66	132	70	11
4	Open chimney DGF 10 kW	94	211	101	8
5	ILFE 6.9 kW (9000mm2)	38	93	42	13
6	ILFE 10 kW (9000mm2)	40	106	43	10
7	Wood stove into unlined chimney (5kW)	10	29	11	0.8
8	Wood stove into unlined chimney (10kW)	10	58	12	0.6
9	Radiant gas fire 125mm flue 10 kW	28	83	32	6
10	ILFE 125mm flue 6.9 kW	28	82	31	8.1
11	Wood chip boiler 15 kW, 80% efficiency, into 125 mm flue	10	82	22	4

Cases 1 and 2 are for open chimneys using solid fuels in a grate, or other form of open fire, for which ADJ specifies a ventilator area in the room of half the throat area. The throat itself is the only restriction at the appliance and is typically 12 by 4 inches in the UK, giving an area of 31,000 mm^2 and a ventilator area of 16,500 mm^2. The calculated flow rate when there is no fire is more than twice that assumed in SAP. An analogy can be made with a 125 mm passive stack ventilator, as used in a kitchen, to which ADF attributes a flow rate of 47 m^3/hour. If this is adjusted pro-rata for the throat area of the chimney, it yields a result of 118 m^3/hour, which is even larger than the result in Table 3 for the no fire condition. By contrast, the result for the full firing condition is relatively low compared to those given on the American websites referred to earlier. This may be due to the relatively low firing rates used and, especially in the 10 kW case, appears to be significantly constrained by the pressure drop due to the air path into the room.

Cases 3 and 4 are also for open chimneys but fitted with decorative gas fires (DGF), as shown in Figure 2, item (c). The main difference from cases 1 and 2 is the size of room ventilator required. The appliance assumed for case 3 is assumed to require no additional ventilation into the room, being under 7 kW and compliant with the conditions set out paragraph 3.12 of ADJ. This has the effect of reducing the air flow, especially under no fire conditions. Case 4 has a larger appliance which requires the addition of a 10,000 mm^2 ventilator, which makes it more comparable to that for cases 1 and 2. Taking cases 1 to 4 together, the most significant fact is that all have flow rates in the no firing condition that are much higher than is assumed in SAP, even when no additional ventilation into the room is required in case 3.

Cases 5 and 6 are for inset live fuel effect gas fires (ILFE), as described in Figure 2, item (b), operating into an unlined chimney. Unlike the DGF types in cases 3 and 4, ILFE fires significantly restrict the airflow into the chimney opening. The extent of this restriction probably varies considerably from model to model but for the purpose of this calculation was assumed to be 9000 mm^2, which is the area of a 7 by 2 inch "letterbox" opening. As for case 3, case 5 does not require additional ventilation into the room because the consumption rate of the appliance is below 7 kW. Case 6 does require additional ventilation but only 1500 mm^2 (500 mm^2/kW in excess of 7kW) compared to the 10,000 mm^2 in case 4. The effect of the restriction in the appliance is clearly evident in the reduced air flow, both when firing and when not. It is important to note, however, that the reduced rates achieved are comparable to those assumed by SAP for an open chimney, rather than for an appliance with restricted flow.

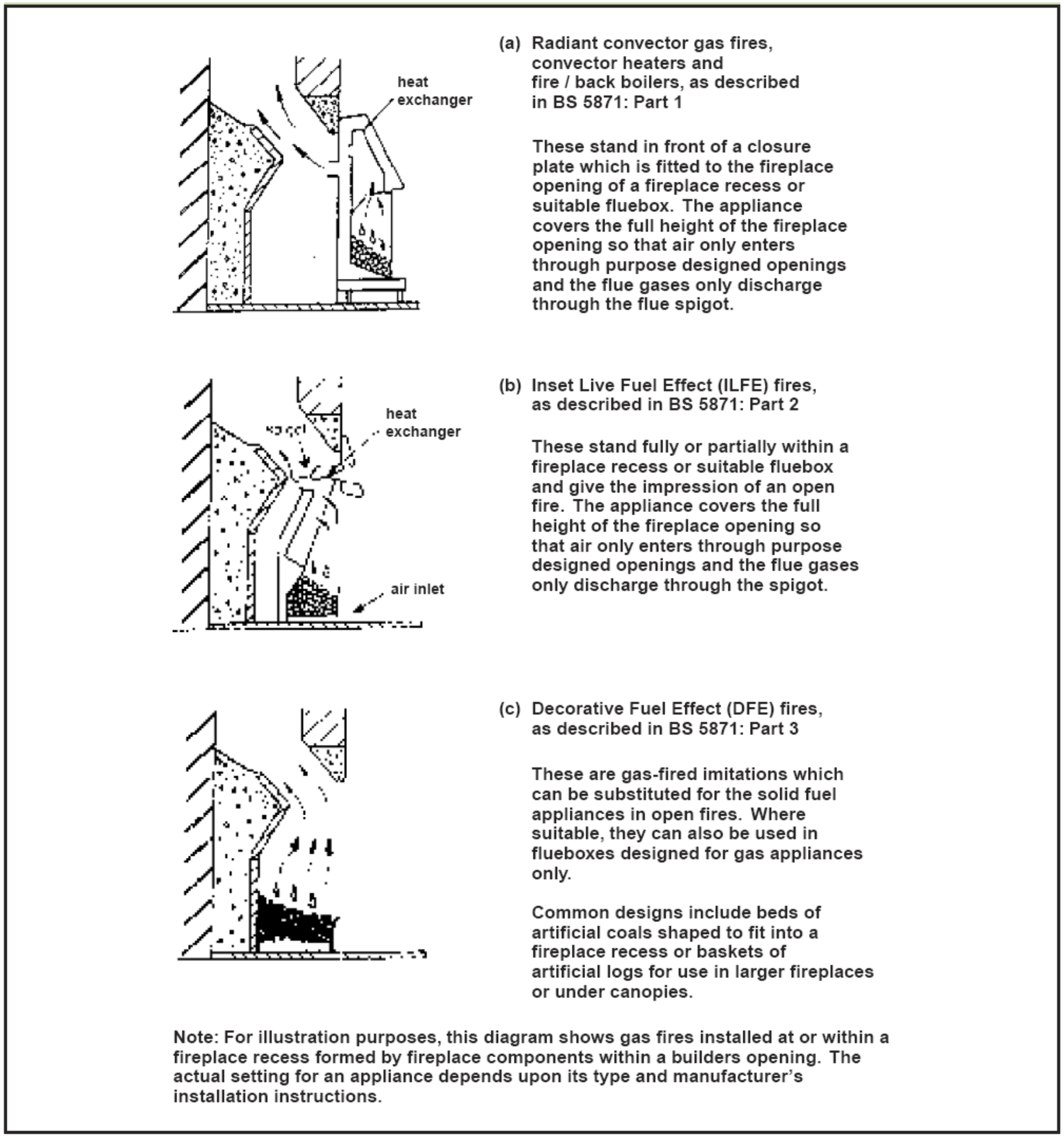

Figure 2: Types of gas fire, copied from Diagram 3.1 of ADJ

Cases 7 and 8 are for a small modern wood burning stove, coupled to an unlined chimney through a short length of flue and a register plate, which ensures at the only air path into the chimney from below is through the appliance. Stoves of this type achieve high combustion efficiency by good control of airflow through the appliance. The same dampers used to control airflow during combustion can be used to reduce it to a very low level when the appliance is not firing. No data on the size of air inlets is normally given for wood burning stoves but, as they claim to have high efficiency, it may be assumed that they operate with relatively low excess air ratios. For 50% excess air, it may be calculated that a 1 kW burn rate requires an air supply of around 1.4 m3/hour. The results shown assume effective areas through the appliance of 2000 mm and 4000 mm for 5 kW and 10 kW burn rates, respectively. Even those relatively small areas pass air at a much greater rate than is required for combustion but add only modestly to the ventilation rate. The effect of the high degree of restriction in the appliance may also be observed in the low pressure drop into the room.

Cases 9 and 10 are for gas fires connected to a 125 mm flue liner installed in a chimney. The area through the appliance is assumed to be 9000 mm^2, as for cases 5 and 6. Although the calculated flows are lower than obtained for cases 5 and 6, they are still above the 20 m^3/hour assumed by SAP for flue. This may be because the appliance area is too large; data from manufacturers, or preferably measurements, are needed to establish whether or not this is so.

Case 11 is for a high efficiency wood pellet boiler. It is largely speculative in that it is hard to find any data on the air drawn by this type of appliance. The high efficiency requires, however, that excess air is limited and its contribution to ventilation will be low.

Taken together, the calculations show that the flow restriction at the appliance is a key factor determining the contribution to ventilation rate. Figure 3 shows the calculated air flow through a standard 8 inch chimney with no fire against the area of the restriction at the appliance with and without additional ventilation into the room. The range of areas covered extend from 2,000 mm^2, which might be appropriate for a well restricted appliance such as a wood burning stove, to 35,000 mm^2, which is around 13% larger than a standard chimney throat. The case with no additional ventilator assumes infiltration into the room directly and indirectly equivalent to that from 10,000 mm^2 of openings. The other case is for an open fire and is the ventilator area is set at half the throat area of 31,000 mm^2. For restricted appliances, the air flow through the chimney depends strongly on the area of restriction and relatively little of the presence of additional ventilator. This supports the case for adjusting the contribution to ventilation in SAP using accredited test result for individual appliance types. For unrestricted appliances, such as decorative gas fires, the presence of the additional ventilator becomes significant, even when the appliance is not firing.

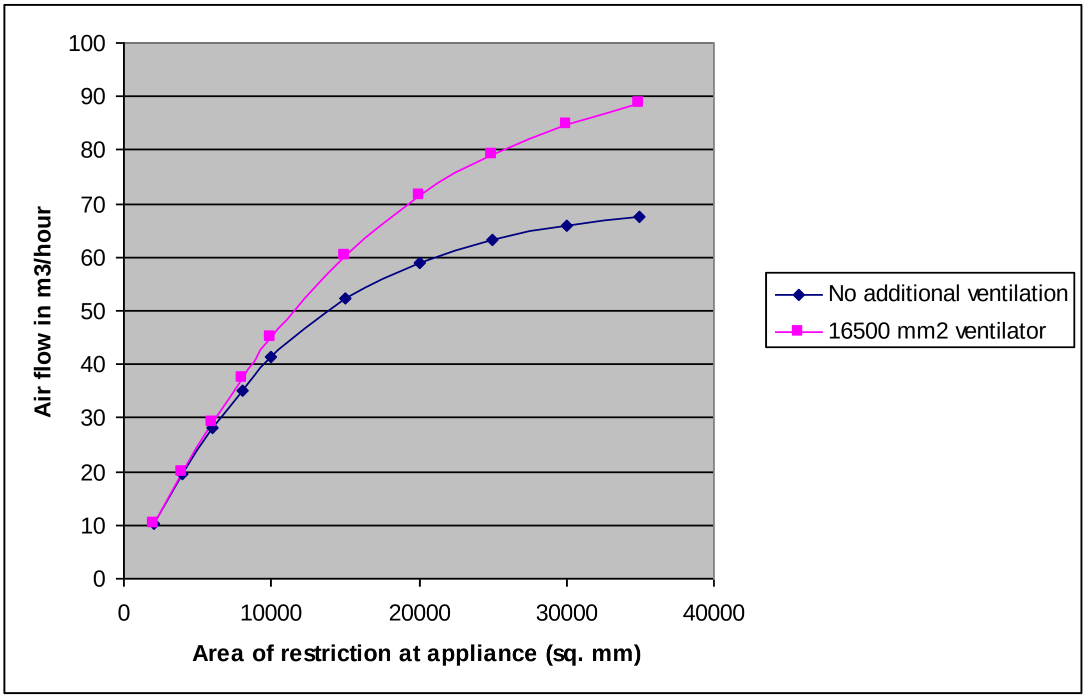

Figure 3: Calculated air flow against area of restriction at the appliance

Incorporation of test results into SAP

For SAP, test results are of principal interest when the restriction through the appliance is the dominant factor in determining air flow. This is most clearly so when the area of the restriction is less than 15,000 mm^2, which is approximately 50% greater than a typical letterbox opening for a gas fire. In this region, the air flow in m^3/hour through a standard 8 inch diameter chimney during no firing conditions may be obtained from

$$Q = (5.2A - 0.0001A^2)/1000 \qquad (6)$$

where A is the effective area through the appliance in square millimetres measured a 4 Pa.

A similar relationship is found for an appliance is connected to a 125 mm diameter flue

$$Q = (4.4A - 0.00014A^2)/1000 \qquad (7)$$