Consultation Paper: CONSP:14

Proposed revisions to SAP Appendix P

Issue 1.0

DOCUMENT REVISIONS

Documents will be revised by issue of updated editions or amendments. Revised documents will be posted on the website at www.bre.co.uk/sap2016.

Technical or other changes which affect product recognition requirements (for example) will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

Users of this document should ensure that they possess the latest issue.

DOCUMENT REVISION LOG

DATE	VERSION NO.	AMENDMENT DETAILS	APPROVED BY
28/06/16	1.0	First Issue	Paul Davidson

TABLE OF CONTENTS

1. INTRODUCTION

Appendix P in SAP “Assessment of internal temperature in summer” was developed as a simple means to provide a method for assessing the propensity of a house to have a high internal temperature in hot weather, primarily with the intent to minimise energy use (mechanical cooling). Recent evidence has indicated that the Appendix P assessments may be under-reporting the risk of high internal temperatures, so there is a need to review the methodology or consider other options, including its removal.

The Zero Carbon Hub has recently undertaken research and issued a report on the problems facing house builders with regard to overheating [1]. Appendix P was intended to be a simple tool to predict the likelihood of high internal temperatures. It was not conceived as a comprehensive ‘overheating assessment’ and therefore should not be relied upon by designers as a means to ensure thermal comfort. The calculation is a balance between the heat gains made within the dwelling and its capacity to reject heat. This is then applied as a modifier to the average external temperature, and a risk is ascribed to the dwelling depending upon the temperature calculated. The risk profile has previously been compared to the results of detailed simulations and found to compare well with exceedance of the overheating criteria given in the previous version of CIBSE Guide A 2006 [2], commonly used in industry. Nonetheless, it is seen by the industry as being too imprecise, with potential to ‘game’ the system or enter optimistic assumptions based on the questions it asks being too vague:

‘Housing Providers and experts raised many concerns with Appendix P. The view, summarised by the quote ‘no one fails Appendix P’ suggests the process is not separating out properties which are genuinely at risk of overheating as effectively as it could. Stakeholders considered that the assessment is too easy to pass and, as currently structured, allows assumptions to be included that are unrealistic. For example, that windows are constantly open. The result is that a ‘low risk’ assessment may be given inappropriately.’

Zero Carbon Hub, 2015, Overheating in Homes - The Big Picture

Given there is no evidence to support such views on how the requirement is being enforced, concerns about shortcomings of the methodology need to be investigated.

The methodology does not undertake an hourly calculation and is not specific to any particular parts of dwelling (in common with the rest of the SAP methodology). Such calculations are beyond the current capability of SAP. If it is considered that a more complex assessments are required then they should be derived using industry provided simulation software or some other more complex estimation of the overheating potential in the dwelling.

Consequently, this document relates solely to improvements in data entry of the Appendix P methodology; it does not consider modifications to the fundamental procedure.

Some contributors to overheating risk not currently considered in Appendix P are influenced by the surroundings of the dwelling, such as noise, pollution, and security risk. Other components such as mechanical ventilation flow rate and blind closing rate may be subject to overestimation. The following elements of the methodology are considered:

- Questioning on the potential for natural ventilation to guard against overestimating it.
- Evidence that mechanical ventilation systems have the capability to purge vent the dwelling to the capacity required.
- Assumptions on the amount of time that blinds are closed during the day.

This document therefore discusses options for modifying these inputs.

2. PROPOSED AMENDMENTS

Natural Ventilation

The SAP 2012 options for estimation of natural ventilation are shown in Table 1. The 2012 Appendix P also states:

'Cross ventilation can be assumed only if at least half of the storeys in the dwelling have windows on opposite sides and there is a route for the ventilation air. Normally bungalows and two storey houses can be cross ventilated because internal doors can be left open. Three storey houses and other situations with two connected storeys of which one is more than 4.5 m above ground level often have floors which have fire doors onto stairs that prevent cross ventilation.'

Table 1 SAP 2012 Appendix P Table P1 (figures are air changes per hour)

	Trickle vents only	Windows slightly open (50 mm)	Windows open half the time	Windows fully open
Single storey dwelling, Cross ventilation possible	0.1	0.8	3	6
Single storey dwelling, Cross ventilation not possible	0.1	0.5	2	4
Dwelling of two or more storeys, windows open upstairs and downstairs, Cross ventilation possible	0.2	1	4	8
Dwelling of two or more storeys, windows upstairs and downstairs, Cross ventilation not possible	0.1	0.6	2.5	5

The calculation is made assuming a sustained air change rate over the course of 24 hours. Window opening is often not practical when in the presence of noise, or in a position of security risk. There are no checks on this under the current procedure but they could and possibly should feature. Therefore we propose that the determination of effective air change rate should be remodelled as a series of questions to reflect more closely what the potential is for natural purge ventilation.

It is important to note that diverse issues can affect occupant comfort and it is difficult to quantify these in an objective manner. The emphasis of the proposed changes is upon improving the level of questioning compared to the previous Appendix P, while keeping the burden on the assessor low. It is acknowledged that this will lead to a degree of subjectivity in the answers, although this will be reduced compared to the previous situation. The proposed modified text for use in SAP 2016 is given in Appendix A of this document.

1. Is there a local noise nuisance likely to cause irritation to occupants?

   There is no single definition of dB limits that would constitute ‘nuisance noise’, and irritation due to noise can depend on several factors of its character. Noise assessments and proximity to typical noise sources must therefore be used as a proxy for this.

   Documents such as The Noise Policy Statement for England [3] may be mentioned in local planning policy, and may require a noise assessment to be undertaken in support of a planning application for a development. If so this should be used as evidence. If noise has been detected at or above ‘Lowest observed adverse effect level’, or any other indication of noise nuisance is given in the report, then this should be assumed to cause irritation to the occupants. The resources in [4, 5, 6, and 7] may also provide supporting evidence of nuisance noise. If this is so then it should be assumed that windows will not be left open and ‘trickle vents only’ should be selected.

   If no such evidence is available, the assessor must answer the following question to the best of their knowledge: Is the dwelling in close proximity (<20m) to a source of nuisance noise such that occupants are likely to keep their windows closed? A well-used road, railway, and industrial works are examples of noise nuisances, and if any of these are present, then ‘trickle vents only’ should be selected.

2. Is there a local security risk?

   Householders need to be confident they can use natural ventilation without it posing a security risk when they are present or not present. An example of where this would likely not be the case is a ground floor flat in an urban location. As guidance, any window or door classed as ‘easily accessible’ under Approved Document Q [8] could not be left open unattended, including those accessible on upper floors[1]. If the property is single storey and ground floor then 'trickle vents only' should be selected. If the property has two storeys, then one of the 'single storey dwelling' rows should be chosen to reflect reduced ventilation due to ground floor windows being closed. However, if suitably certified security grilles are fitted to all such windows, these may be left open when the occupier is not present and there may not be constraints from a security point of view.

3. What is the extent to which windows can be left open?

   It is unlikely that all windows in a dwelling can be kept wide open 100% of the time (24 hours a day) under any circumstances. It is therefore proposed to remove this option, revising the upper limit to windows **fully open 50% of the time** as a realistic maximum for the monthly calculation. The options available are therefore: fully open 50% of the time, 50mm open 100% of the time, and ventilation through trickle vents only. These airflow figures are consistent with those in the existing categories.

The number of storeys in the dwelling is obtained from previous data entry and in combination with the answers above the ventilation rate is obtained from Table 1. It is expected that software will implement the questions above and select the correct air change rate, such that there is no need for the assessor to lookup data from a table and enter it themselves.

Blinds

Blinds and curtains can be assumed by assessors to be closed for 100% of daylight hours for the SAP 2012 Appendix P calculation, and this has been questioned as unrealistic by industry in the ZCH consultation. No literature could be found on occupant blind closing patterns in the UK, but a US DOE study [9] found that 87% of occupants interviewed in a 2,467 sample covering three different climate zones left their blinds in the same position every day over each season, and that the summer positions are as Table 2. In the absence of UK based data, it is proposed to use these figures.

[1] Upper floor windows that may be accessed by climbing on adjoining garages or other low roofs from ground level are also defined as 'easily accessible'.

Table 2 Occupier blind closing patterns in summer, DOE study 2013

	Summer Weekday (%)			Summer Weekend (%)		
	Morning	Afternoon	Evening	Morning	Afternoon	Evening
Open	22	20	18	22	21	19
Half open	31	30	28	32	31	29
Closed	47	49	54	46	48	52

The SAP calculation is made on a whole house, daily average basis. Assuming averages of the morning afternoon and evening figures for both weekdays and weekends in Table 2, the blinds would be approximately 50% closed, 30% half closed and 20% open. Area weighting the figures would give an overall blind closing proportion of **65%** and it is proposed that this figure is used for Appendix P calculations in future as a more conservative and likely figure.

Mechanical Ventilation

Evidence for air flow rate will need to be substantiated with manufacturer literature, and relates to a whole house ventilation rate that can be *maintained continuously* during hot weather.

3. IMPACT OF PROPOSED CHANGES

The general impacts associated with the proposed changes to Appendix P are:

- It is more difficult to estimate non-conservative figures where natural ventilation is used
- It will be more likely that a calculation gives a higher risk of high internal temperatures
- Specific 'problem locations' near to sources of noise pollution or posing a security threat will yield a higher risk of a naturally ventilated dwelling having high internal temperatures.
- For some 'problem locations' where security and noise or pollution issues are present the only option to pass the internal temperature criterion will be to install dedicated purge ventilation, as background ventilation and high purge ventilation rates can have contradictory requirements for ductwork sizing.

This will affect assessments for dwelling forms in different ways. If a dwelling is in a comparatively cool degree day region high internal temperatures remain less likely. However, for a naturally ventilated dwelling in a warm degree day region and an urban environment, external factors such as noise, air pollution and security will have a major effect upon the capacity to ventilate through the windows, and may mean mechanical purge ventilation has to be installed.

Example

As an example of the effect upon any specific assessment, consider the following example:

Element	**Specification**
House type	Detached 2 storey
Region	Thames (warmest region in UK)
Walls	U-value 0.18W/m^{2}K, 150m^2
Windows	U-value 1.4W/m^{2}K, 16m^2, primarily East/West orientation, no significant overhangs, average over shading
Roof	U-value 0.13W/m^{2}K, 52m^2
Floor	U-value 0.13W/m^{2}K, 52m^2

Ventilation	Natural ventilation
Airtightness	5 $m^3/h/m^2$

Under the existing Appendix P questions the result could be:

Element	**Specification**
Blinds	Dark curtain, 100% closed
Window opening	Windows open 100% of the time (5 air changes)
Threshold temperature (warmest month)	20.32°C
Result	**Not significant**

Under the proposed revisions the baseline result would be:

Element	**Specification**
Blinds	Dark curtain, 65% closed
Window opening	Windows open 50% of the time (2.5 air changes)
Threshold temperature (warmest month)	22.06°C
Result	**Medium**

However, if there were significant issues of noise or security likely to prevent occupants leaving windows open, the result would be:

Element	**Specification**
Blinds	Dark curtain, 65% closed
Window opening	Trickle vents only (0.1 air changes)
Threshold temperature (warmest month)	31.75°C
Result	**High**

In order to make the example above pass, a mechanical ventilation system would need to supply an additional **1.5 air changes** to reduce the resulting risk level to medium.

The proposed calculation considers:

- Natural ventilation capability (maximum ventilation capability has been reduced)
- Mechanical ventilation capability

- Blind use (a more conservative assumption is now used for blind closing rate)

In combination these factors will make it less likely that the methodology returns a low risk of high internal temperatures, and will return a more appropriate estimation of risk.

4. CONCLUSION

The proposed modifications to Appendix P address several points raised by the Zero Carbon Hub study. They ask more detailed questions of the assessor and the inputs are likely to become more conservative for problematic dwellings, but the underlying methodology has not been made more complex.

As the example shows, for dwellings in specific locations the changes to the questions can have significant effects. A dwelling that was previously deemed ‘not significant’ in risk could become ‘high’ risk given the presence of noise, pollution or security issues, and adequate mechanical purge ventilation will become necessary to mitigate this risk.

These modifications are proposed as a reasonable progression for SAP’s consideration of summer internal temperatures in the context that further supporting models are needed for a more detailed calculation of overheating risk for housing developers.

5. REFERENCES

1. Zero Carbon Hub, June 2015, "Overheating in homes – The big picture" http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingInHomes-TheBigPicture-01.1.pdf
2. CIBSE, 2006, Guide A. "Environmental design."
3. DEFRA 2010, "Noise Policy Statement for England", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69533/pb13750-noise-policy.pdf
4. English Noise Mapping http://services.defra.gov.uk/wps/portal/noise/
5. Welsh Noise Mapping http://data.wales.gov.uk/apps/noise
6. Scottish Noise Mapping http://www.scottishnoisemapping.org/
7. Northern Ireland Noise Mapping http://applications.noiseni.co.uk/webviewer/mapwebviewer.aspx
8. Approved Document Q, 2012 edition http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_Q_2015.pdf
9. D&R International for DOE, October 2013, "Residential Windows And Window Coverings: A Detailed View Of The Installed Base And User Behavior" http://energy.gov/sites/prod/files/2013/11/f5/residential_windows_coverings.pdf

Appendix A: Proposed revised SAP Appendix P methodology

The methodology is given here as presented in the SAP 2012 Appendix P. Proposed changes to the methodology are highlighted.

P1 Assessment procedure

The procedure is undertaken for the months of June, July and August. Weather data is that of the region in which the property is situated (Tables U1 to U4).

1. Obtain a value for the effective air change rate during hot weather (n). Indicative values based on the procedure in BS 5925[2] are given in Table P1. Select the appropriate airflow rate having answered the following questions:

- Is there a local noise nuisance likely to cause irritation to occupants?
    a. If a noise assessment has been required in support of a planning application for the development, this should be used as evidence. If any indication of noise nuisance is given in the report, then this should be assumed to cause irritation to the occupants. If this is so then 'trickle vents only' should be selected.
    b. If no such noise assessment is available, is the dwelling in close proximity (<20m) to a road, railway, industrial site, under a major airport flight path, or other obvious source of noise, such that occupants are likely to need to keep their windows closed? If this is so then 'trickle vents only' should be selected.
- Is there a local security risk?
    a. Any window or door classed as 'easily accessible' under Approved Document Q could not be left open unattended if the terrain type is 'urban' or 'semi-urban', unless appropriately certified security grilles are fitted. Note that the definition of 'easily accessible' includes some upper floor windows. If the property is single storey and ground floor then 'trickle vents only' should be selected. If the property has two storeys, then one of the 'single storey dwelling' rows should be chosen to reflect reduced ventilation due to ground floor windows being closed.
- What is the extent to which windows can be left open?
    a. The options available are: fully open 50% of the time, 50mm open 100% of the time, and ventilation through trickle vents only.

---

[2] BS 5925:1991, Code of practice for ventilation principles and design for natural ventilation

Table P1: Effective air change rate

Window Opening	Effective air change rate in ach		
	Trickle vents only	**Windows slightly open (50 mm)**	**Windows open 50% of the time**
Single storey dwelling (bungalow, flat) Cross ventilation possible	0.1	0.8	3
Single storey dwelling (bungalow, flat) Cross ventilation not possible	0.1	0.5	2
Dwelling of two or more storeys Windows open upstairs and downstairs Cross ventilation possible	0.2	1	4
Dwelling of two or more storeys Windows open upstairs and downstairs Cross ventilation not possible	0.1	0.6	2.5

If there is a mechanical ventilation system providing a specified continuous air change rate, that rate can be used instead. The information must be substantiated with manufacturer literature on the boost rate that can be continuously attained.

2. Calculate the ventilation heat loss, H_v^{summer} , using the formula:

$$H_V^{summer} = 0.33 \times n \times V \qquad (P1)$$

Where:

n = air change rate during hot weather, ach

V = volume of the heated space of the dwelling, m^3

3. Calculate the heat loss coefficient under summer conditions:

$$H = \text{total fabric heat loss} + H_v^{summer} \qquad (P2)$$

The total fabric heat loss is the same as for the heating season (worksheet (37)).

4. Calculate the solar gains for the summer month, $G_{solar}^{\ summer}$, using the solar flux for the appropriate month and climate region from Table U3.

$$G_{solar}^{\ summer} = \sum (0.9 \times Aw \times S \times g \times FF \times Z_{summer}) \qquad (P3)$$

Where:

0.9 is a factor representing the ratio of typical average transmittance to that at normal incidence

A_w is the area of an opening (a window, roof window or fully glazed door), m²

S is the solar flux on a surface during the summer period from Appendix U3.2, W/m²

g^ is the total solar energy transmittance factor of the glazing at normal incidence from Table 6b

FF is the frame factor for windows and doors (fraction of opening that is glazed) from Table 6c

Z_{summer} is the summer solar access factor

In the case of a window certified by the British Fenestration Rating Council (BFRC), see www.bfrc.org, the quoted solar factor is g_{window} which is equal to 0.9 × g^ × FF. The solar gain for such windows is calculated as

$$G_{solar}^{summer} = \sum (A_w \times S \times g_{window} \times Z_{summer}) \quad \text{(P4)}$$

Solar gains should be calculated separately for each orientation, and totalled according to equation (P3).

For data to calculate Z_{summer} see section P3.

Assume that the summer internal gains (G_i) are equal to the winter internal gains (these are calculated in section 5 of the SAP worksheet), except that

- where water heating in summer is by a summer-only electric immersion primary loss is not included in the summer gains, and

- gains associated with heating systems (Table 5a) are not included in the summer gains, so that the total gains are:

$$G = Gsolar^{summer} + Gi \quad \text{(P5)}$$

5. Calculate the summer Gain/Loss ratio:

$$\text{Summer Gain/Loss ratio} = H/G \quad \text{(P6)}$$

6. Obtain the mean external temperature for the month and climate region, $T_e^{\ summer}$, from Table U1.

7. Obtain the threshold internal temperature which is used to estimate likelihood of high internal temperature. This is the mean internal temperature during the summer period plus an increment related to the thermal mass.

$$T\ threshold = T_e^{summer} + G/H + \Delta\ T_{mass} \quad \text{(P7)}$$

Where

$\Delta\ T_{mass} = 2.0 – 0.007 \times TMP$ if TMP < 285

$\Delta\ T_{mass} = 0$ if TMP >= 285

Where TMP is the thermal mass parameter (for further details see Table 1e).

Where night cooling can be employed (window opening at night) $\Delta\ T_{mass}$ is further modified if TMP > 285 by a term – 0.002 × (TMP – 285).

8. Use Table P2 to estimate tendency to high internal temperature in hot weather.

Table P2: Levels of threshold temperature corresponding to likelihood of high internal temperature during hot weather

$T_{threshold}$	Likelihood of high internal temperature during hot weather
< 20.5°C	Not significant
≥ 20.5°C and < 22.0°C	Slight
≥ 22.0°C and < 23.5°C	Medium
≥ 23.5°C	High

P2 Reporting of results

Results should include:

- details of the house design including its thermal mass parameter and specification of any overhangs, together with its orientation and the climatic region assumed;
- for one or more scenarios, the category from Table P2 for the months of June, July and August for stated assumptions on occupant-determined factors (usage of blinds/curtains and window opening).

P3 Solar shading

Z_{summer} is given by

$$Z_{summer} = Z_{blinds} (Z + Z_{overhangs} - 1) \qquad (P8)$$

subject to

$$Z_{summer} \geq 0.1\ Z_{blinds} \qquad (P9)$$

where

Z_{blinds} is a shading factor for blinds or curtains

Z is the solar access factor from Table 6d

$Z_{overhangs}$ is a shading factor for overhangs

Table P3 gives values for Z_{blinds}, and Tables P4 and P5 give values for $Z_{overhangs}$. If there are no overhangs, $Z_{overhangs}$ =1.

P3.1 Curtains and blinds

Unless the blind or curtain type is specifically included in the design specification a default of dark coloured curtains should be assumed. Blinds or curtains shall be assumed closed 65% of the time during daylight hours (f = 0.65). Shutters with window closed is compatible with windows open half the time in Table P1 as the latter refers to night-time and Table P3 refers to daytime.

Table P3 : Shading factors for blinds, curtains or external shutters

Blind or curtain type	Z_{blind}
Net curtain (covering whole window)	0.80
Net curtain (covering half window)	0.90
Dark-coloured curtain or roller blind (note 1)	0.85
Light-coloured curtain or roller blind (note 1)	0.60
Dark-coloured venetian blind (note 2)	0.88
Light-coloured venetian blind (note 2)	0.70
Dark-coloured external shutter, window closed (notes 1, 3)	0.27
White external shutter, window closed (notes 1, 3)	0.24
Dark-coloured external shutter, window fully open (notes 1, 3)	0.85
White external shutter, window fully open (notes 1, 3)	0.65

Notes to Table P3

1. Factor applies when fully closed. If closed only for a fraction f of the daylight hours or applicable only to a fraction f of the windows use

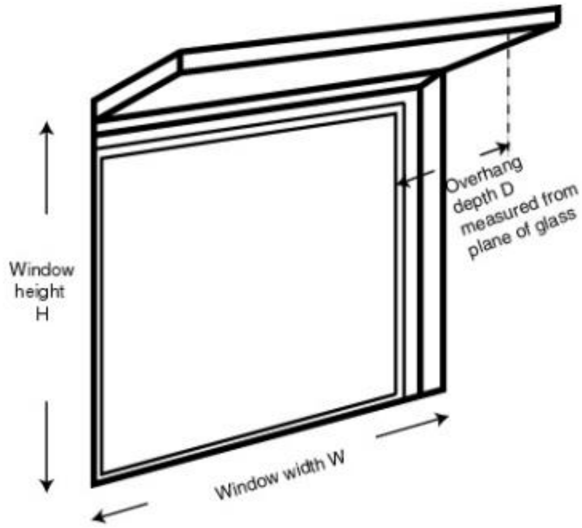
   $f \times Z_{blind} + (1 - f)$.

2. Factor applies for venetian blind with slats at 45° against the sun. The same factor can be used if the blind is fully closed. If closed only for a fraction f of the daylight hours or applicable only to a fraction f of the windows use

   $f \times Z_{blind} + (1 - f)$.

3. External shutters are not applicable to roof windows.

P3.2 Overhangs



Where the overhang is at least twice as wide as the window (e.g. balconies on blocks of flats) use Table P4. In other cases use Table P5. Interpolation may be used between rows of these tables. Use the average overhang depth if it varies. Usually the same value of overhangs can be applied to all the windows on a given façade on the basis of an average depth-to-height ratio. This can be applied only to windows whose orientation is known.

Table P4: $Z_{overhangs}$ for wide overhangs

Depth/H	Orientation of window				
	N	NE/NW	E/W	SE/SW	S
0.0	1.00	1.00	1.00	1.00	1.00
0.2	0.92	0.89	0.88	0.83	0.77
0.4	0.85	0.80	0.76	0.67	0.55
0.6	0.79	0.72	0.66	0.54	0.38
0.8	0.73	0.65	0.58	0.43	0.32
1	0.69	0.59	0.51	0.36	0.30
1.2 or more	0.66	0.55	0.46	0.31	0.29
This table is to be used where the overhang is at least twice as wide as the window					

Table P5: $Z_{overhangs}$ for normal overhangs

Depth/H	Orientation of window				
	N	NE/NW	E/W	SE/SW	S
0.0	1.00	1.00	1.00	1.00	1.00
0.2	0.94	0.91	0.89	0.84	0.79
0.4	0.90	0.85	0.79	0.72	0.64
0.6	0.88	0.81	0.72	0.62	0.53
0.8	0.86	0.79	0.66	0.55	0.50
1	0.85	0.77	0.61	0.52	0.49
1.2 or more	0.84	0.76	0.57	0.50	0.48
This table is to be used where the overhang is less than twice as wide as the window					