Appendix P: Assessment of internal temperature in summer

This appendix provides a method for assessing the propensity of a house to have high internal temperature in hot weather. It does not provide an estimate of cooling needs. The procedure is not integral to SAP and does not affect the calculated SAP rating or CO_2 emissions.

The calculation is related to the factors that contribute to internal temperature: solar gain (taking account of orientation, shading and glazing transmission); ventilation (taking account of window opening in hot weather), thermal capacity and mean summer temperature for the location of the dwelling.

Further information about techniques to avoid overheating can be found in ‘Reducing overheating– a designer’s guide’, CE 129, Energy Efficiency Best Practice in Housing, Energy Saving Trust, London (2005).

P1 Assessment procedure

1) Obtain a value for the effective air change rate during hot weather. Indicative values based on the procedure in BS 5925* are given in Table P1.

Table P1: Effective air change rate

Window opening	Effective air change rate in ach			
	Trickle vents only	Windows slightly open (50 mm)	Windows open half the time	Windows fully open
Single storey dwelling (bungalow, flat) Cross ventilation possible	0.1	0.8	3	6
Single storey dwelling (bungalow, flat) 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 open upstairs and downstairs Cross ventilation not possible	0.1	0.6	2.5	5

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Cross ventilation can be assumed only if the 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 or 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 on to stairs that prevent cross ventilation.

Slightly open refers to windows that can be securely locked with a gap of about 50 mm. Often this option will not give sufficient ventilation.

Windows on ground floors cannot be left open all night because of security issues. Windows on other floors can. Fully open would refer to dwellings where security is not an issue (e.g. an upper floor flat) or where there is secure night time ventilation (e.g. by means of grilles, shutters with vents or purpose-made ventilators). In most cases where there are ground and upper floor windows ‘windows open half the time’ would be applicable, which refers principally to night-time ventilation (ground floor evening only, upper floors open all night.

* BS 5925:1991, Code of practice for ventilation principles and design for natural ventilation

If there is a mechanical ventilation system providing a specified air change rate, that rate can be used instead.

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 (box (35) of the worksheet).

4) Calculate the total solar gains for the summer period, G_{solar}^{summer}, using the solar flux for the summer period from Table 6a.

$$G_{solar}^{summer} = \sum \left(0.9 \times A_w \times S \times g_\perp \times FF \times Z_{summer}\right) \qquad (P3)$$

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 Table 6a, W/m²
$g_\perp$ 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

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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 $0.9 \times g_\perp \times FF$. The solar gain for such windows is calculated as

$$G_{solar}^{summer} = \sum \left(A_w \times S \times g_{window} \times Z_{summer}\right) \qquad (P4)$$

Solar gains should be calculated separately for each orientation and for rooflights, 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 in which case primary loss should not be included in the summer gains, so that the total gains are:

$$G = G_{solar}^{summer} + G_i \qquad (P5)$$

5) Calculate the summer Gain/Loss ratio:

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

6) Obtain the summer mean external temperature, T_e^{summer}, from Table P2.

Table P2: Summer mean external temperature

Region	**Mean external temperature, T_e^{summer}, used for estimating mean internal**

	temperature in summer
Thames valley	17
Severn valley; South, South East, South West England	16
Midlands; East Anglia; East Pennines; West Pennines	15.5
North West, North East England; Borders	14
Wales, Northern Ireland, East, West Scotland	14
North East Scotland; Highland; Western Isles	13
Orkney	12
Shetland	11

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.

$$T_{threshold} = T_e^{summer} + \frac{G}{H} + \Delta T_{mass} \qquad \text{(P7)}$$

where

$\Delta T_{mass} = 2.0 - 0.2 \times TMP$ if $TMP < 10$

$\Delta T_{mass} = 0$ if $TMP \geq 10$

TMP typically varies between 5 for lightweight construction to 20 for heavy construction. For further details see section P4.

8) Use Table P3 to estimate tendency to high internal temperature in hot weather.

Table P3: 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 P3 for stated assumptions on occupant-determined factors (usage of blinds/curtains and window opening).

If the orientation of the dwelling is not known, the assessment should be for the orientation giving the greatest tendency to high internal temperature.

P3 Solar shading

Z_{summer} is given by

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

subject to

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

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 P4 gives values for Z_{blinds}, and Tables P5 and P6 give values for $Z_{overhangs}$. If there are no overhangs, $Z_{overhangs} = 1$.

P3.1 Curtains and blinds

Unless specifically included in the design specification a default of dark coloured curtains should be assumed closed during daylight hours (f = 1). Shutters with window closed is compatible with windows open half the time in Table P1 as the latter refers to night-time and Table P4 refers to daytime.

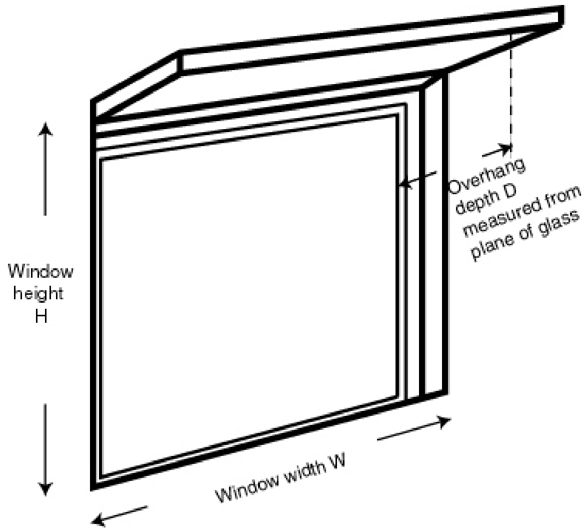
Table P4 : Shading factors for blinds, curtains or external shutters

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 (note 3)	0.24
White external shutter, window closed (note 3)	0.27
Dark-coloured external shutter, window fully open (note 3)	0.85
White external shutter, window fully open (note 3)	0.65

Notes to Table P4

1. Factor applies when fully closed. If closed only for a fraction f of the daylight hours 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 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 P5. In other cases use Table P6. Interpolation may be used between rows of these tables. Usually the same value of $Z_{overhangs}$ can be applied to all the windows on a given façade on the basis of an average depth-to-height ratio.

Table P5: $Z_{overhangs}$ 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 P6: $Z_{overhangs}$ 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					

P4 Thermal mass

The thermal mass of a building is represented by the thermal mass parameter (TMP). Table P7 gives some indicative values of TMP based on the characteristics of the construction elements. For this purpose the mass of an element is low for admittance less than 2 W/m²K, medium 2 to 3.5 W/m²K and high over 3.5 W/m²K (see Table P8). Note that the threshold temperature is not affected by any increase in TMP above 10.

Table P7: Indicative values of thermal mass parameter

Mass of construction elements					
Ground floor	**External walls**	**Separating walls**	**Internal partitions**	**Illustrative construction**	**TMP** W/m²K
low	low	low	low	suspended timber floor, timber/steel frame walls, plasterboard on timber/steel stud internal partitions	5
medium	low	low	low	solid floor, timber/steel frame walls, plasterboard on timber/steel stud internal partitions	6
medium	low	medium	low	solid floor, masonry external walls (internal insulation), masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	7
medium	medium	medium	low	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	8
medium	medium	high	low	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls dense plaster, plasterboard on timber/steel stud internal partitions	9
medium	high	medium	low	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	10

medium	low	medium	medium	solid floor, masonry external walls (internal insulation), masonry separating walls with plasterboard on dabs, masonry internal partitions with plasterboard on dabs	11
medium	high	high	low	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with dense plaster, plasterboard on timber/steel stud internal partitions	11
medium	medium	medium	medium	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls plasterboard on dabs, masonry internal partitions with plasterboard on dabs	12
medium	medium	high	high	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls dense plaster, masonry internal walls with dense plaster	17
medium	high	high	high	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with dense plaster, masonry internal walls with dense plaster	19

Alternatively, TMP can be calculated from the admittances of the elements comprising the structure of the dwelling. It is defined as

$$\text{TMP} = \frac{\sum \text{AY}}{\text{TFA}} \qquad \text{(P9)}$$

where A and Y are the areas and admittance of each element of the construction and TFA is the total floor area of the dwelling.

Thin elements like windows and doors are omitted from the calculation of Σ AY but, unlike the calculation of Σ AU for heat loss calculations, the sum includes all internal partitions, intermediate floors and party walls and floors. The area of an internal partition includes both sides of the partition. The admittance of a building element is determined primarily by the properties of the layers adjacent to the room. Values for some common constructions are given in Table P8.

Table P8: Y-values for common constructions

Construction (external elements insulated to typical new-build levels)	**Admittance Y (W/m^{2}K)**
Ground floors	
Suspended timber, carpeted	1.4
Suspended timber, laminated	1.7
Slab on ground (insulation above or below slab, screed on top, carpeted	3.2
Slab on ground (insulation above or below slab, screed on top, laminated	3.4
Suspended concrete floor, carpeted	3.0
Suspended concrete floor, laminated	3.2
Exposed floors	
Timber exposed floor, carpeted	1.2
Timber exposed floor, laminated	1.5
External walls - masonry, solid, external insulation	
Solid wall: dense plaster, 200 mm dense block, insulated externally	4.8

Solid wall: plasterboard on dabs, 200 mm dense block, insulated externally	2.5
Solid wall: dense plaster, 210 mm brick, insulated externally	4.1
Solid wall: plasterboard on dabs, 210 mm brick, insulated externally	2.3
External walls - masonry, solid, internal insulation	
Solid wall: dense plaster, insulation, dense block or brick, rendered	1.3
Solid wall: plasterboard on dabs, insulation, dense block or brick, rendered	0.7
External walls - cavity masonry walls, full or partial cavity fill	
Cavity wall: dense plaster, dense block, filled cavity, dense block or brick	5.2
Cavity wall: dense plaster, AAC block, filled cavity, AAC block	3.0
Cavity wall: plasterboard on dabs, dense block, filled cavity, dense block or brick	2.6
Cavity wall: plasterboard on dabs, AAC block, filled cavity, AAC block	2.0
External walls – concrete panel construction (precast or in-situ)	
Plasterboard directly fixed, concrete panel construction	4.5
Plasterboard directly fixed with 5 mm air gap, concrete panel construction	3.1
Plasterboard, internal insulation board, concrete panel construction	0.9
External walls – timber or steel frame	
Timber framed wall (one layer of plasterboard)	0.8
Timber framed wall (two layers of plasterboard)	1.3
Steel frame wall (warm frame construction)	2.0
Steel frame wall (hybrid construction)	1.1
Roofs	
Insulated at ceiling level	0.7
Insulated slope	0.7
Insulated flat roof	0.7
Separating walls	
Dense plaster both sides, dense blocks, cavity (E-WM-1 or E-WM-2)*	5.0
Single plasterboard on dabs on both sides, dense blocks, cavity (E-WM-3 or E-WM-4)*	2.5
Plaster on dabs and single plasterboard on both sides, dense cellular blocks, cavity (E-WM-5)*	2.5
Plasterboard on dabs mounted on cement render on both sides, AAC blocks, cavity (E-WM-6 or E-WM-7)*	2.2
Double plasterboard on both sides, twin timber frame with/without sheathing board (E-WT-1 or E-WT-2)*	1.4
Steel frame (E-WS-1 to E-WS-3)*	1.4
Separating floors (Y from above /Y from below)	
Precast concrete planks floor, screed, carpeted (E-FC-1)*	1.9/1.9
Concrete floor slab, carpeted (E-FC-2)*	2.0/2.7
Precast concrete plank floor (screed laid on insulation), carpeted (E-FC-3)*	2.3/1.9
Precast concrete plank floor (screed laid on rubber), carpeted (E-FC-4)*	2.7/1.9
In-situ concrete slab supported by profiled metal deck, carpeted (E-FS-1)*	1.9/2.7
Timber I-joists, carpeted (E-FT-1)*	1.7/1.4
Internal partitions	
Plasterboard on timber frame	0.8
Dense block, dense plaster	4.6
Dense block, plasterboard on dabs	2.6
Ceiling/floor between floors in a house (Y from above/Y from below)	
Plasterboard ceiling, carpeted chipboard floor	0.9/1.0

* Reference in the Robust Details for Part E “Resistance to the passage of sound”