ACOUSTICS & NOISE CONSULTANTS

Appendix B

B Appendix B – example application of this guide

January 2020

Version 1.0

ACOUSTICS VENTILATION AND OVERHEATING

Residential Design Guide

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Thursday 30th January 2020

15 Hatfields, London

Table B-7 A schedule of performance requirements that may be appropriate to include in a testing schedule

Noise Source	Time Period / function	Living rooms	Bedrooms	Bath,WC, Kitchen
Environmental noise ingress limit with provisions for whole dwelling ventilation rate	Daytime, $L_{Aeq,16h}$	≤ 35 dB	≤ 35 dB	-
	Night-time, $L_{Aeq,8h}$	-	≤ 30 dB	-
	Night-time, ventilation design case L_{AFmax}	-	≤ 45 dB	-
Environmental noise ingress limit with provisions for mitigating overheating	Daytime, $L_{Aeq,16h}$	[Note 1]	[Note 1]	-
	Night-time, $L_{Aeq,8h}$	-	[Note 1]	-
	Night -time, overheating design case L_{AFmax}	-	[Note 1]	-
Mechanical services noise, where systems present	Whole dwelling ventilation rate, $L_{Aeq,T}$	≤ 30 dB	≤ 26 or 30 dB [Note 2]	-
	Extract ventilation rate, $L_{Aeq,T}$	≤ 35 dB	≤ 26 or 30 dB [Note 2]	≤ 45 dB
	At design duty to control overheating [Note 3]	≤ 35 dB	≤ 30 dB	-

Guideline external noise constraints

Guideline external noise constraints for ADF ventilation Systems 1 & 2

B.19 The trickle vent areas indicated in ADF to provide whole dwelling ventilation rates are based on calculated air flow rates for the winter condition; provisions for purge ventilation (i.e. opening windows) may be used at other times of the year.

B.20 Two trickle vents to provide an equivalent area of 5000 mm^2 are assumed for the assessment of Systems 1 & 2. It is noted that the trickle vents are sized based on winter conditions; at other times of the year, partially open windows may be required to avoid poor indoor air quality. However, there is no guidance provided in ADF on the area of opening that may be required; therefore this assessment is based on external noise ingress through closed windows and open trickle vents.

B.21 External levels for use of ADF System 1 are based on calculations according to the detailed method described in BS 8233, (equivalent to the method in BS EN 12354-3) [45] A typical small bedroom is considered. The *Technical housing standards – nationally described space standard* [46] indicates that a single bedroom should be at least 7.5 m^2. The glazed area is considered to 25% of the floor area, as described in SAP.

B.22 These dimensions represent unfavourable ratios between element performance and overall facade level difference, but worse case conditions may be found in practice. On the basis of these assumptions, the relation between element performance and partial internal level ($L_{2,route}$) due to each noise ingress path reduces to the following relationship, following the detailed method in BS 8233 Section G.2:

- $L_{2,\,glass} = L_{1,ff} - (R_w + C_{tr}) - 2$
- $L_{2,\,vent} = L_{1,\,ff} - (D_{n,e,w} + C_{tr}) + 5$ [for each vent]

Table 5.2a System 1 – Background ventilators and intermittent extract fans (for additional information see Table 5.3 and worked examples C1 and C5 in Appendix C)

Background ventilators (follow Steps 1 to 3 below)

Step 1: Determine the total equivalent ventilator area – See Table A below for a dwelling with any design ***air permeability***. As an alternative, the guidance in Table B below may be followed for a dwelling designed to an ***air permeability*** leakier than (>) 5 $m^3/(h.m^2)$ at 50 Pa which recommends less ventilation provisions, but see the cautionary advice in paragraph 5.10.

Step 2: Follow (i) or (ii) as appropriate depending on the number of storeys:

(i) For multi-storey dwellings, and single-storey dwellings more than four storeys above ground level:

- Use the total equivalent ventilator area from Step 1.

(ii) For single-storey dwellings up to and including the fourth storey above ground level:

- Add a further 10000 mm^2 to the total equivalent ventilator area from Step 1, preferably shared between several rooms.

Step 3: For dwellings which have a single exposed façade, or at least 70% of the ***equivalent area*** is designed to be on the same façade, cross-ventilation is not possible, or is limited, and additional ventilation provisions are recommended. In this case ***background ventilators*** should be located at both high and low positions in the façade to provide enhanced single-sided ventilation. The total ***equivalent area*** as described in Steps 1 and 2 above should be provided at the high position (typically 1.7 m above floor level) for all dwelling types and all storey heights. In addition, ventilators having the same total ***equivalent area*** should be provided at least 1.0 m below the high ventilators as shown in Diagram 2b. Single-sided ventilation is most effective if the dwelling is designed so that the ***habitable rooms*** are on the exposed façade, and these rooms are no greater than 6 m in depth.

A – Total equivalent ventilator area [a] (mm^2) for a dwelling with any design air permeability.

Total floor area (m^2)	Number of bedrooms [b]				
	1	2	3	4	5
≤50	35000	40000	50000	60000	65000
51–60	35000	40000	50000	60000	65000
61–70	45000	45000	50000	60000	65000
71–80	50000	50000	50000	60000	65000
81–90	55000	60000	60000	60000	65000
91–100	65000	65000	65000	65000	65000
> 100	Add 7000 mm^2 for every additional 10 m^2 floor area				

B – Alternative guidance on total equivalent ventilator area [a] (mm^2) for a dwelling with a designed air permeability leakier than (>) 5 $m^3/(h.m^2)$ at 50 Pa.

Total floor area (m^2)	Number of bedrooms [b]				
	1	2	3	4	5
≤50	25000	35000	45000	45000	55000
51–60	25000	30000	40000	45000	55000
61–70	30000	30000	30000	45000	55000
71–80	35000	35000	35000	45000	55000
81–90	40000	40000	40000	45000	55000
91–100	45000	45000	45000	45000	55000
> 100	Add 5000 mm^2 for every additional 10 m^2 floor area				

Notes:

a. The ***equivalent area*** of a ***background ventilator*** should be determined at 1 Pa pressure difference, using the appropriate test method given in Table 5.3.

b. This is based on two occupants in the main bedroom and a single occupant in all other bedrooms. For a greater level of occupancy, assume a greater number of bedrooms (i.e. assume an extra bedroom per additional person). For more than five bedrooms, add an additional 10000 mm^2 per bedroom.

Guideline external noise constraints

Guideline external noise constraints for ADF ventilation Systems 1 & 2

B.19 The trickle vent areas indicated in ADF to provide whole dwelling ventilation rates are based on calculated air flow rates for the winter condition; provisions for purge ventilation (i.e. opening windows) may be used at other times of the year.

B.20 Two trickle vents to provide an equivalent area of 5000 mm^2 are assumed for the assessment of Systems 1 & 2. It is noted that the trickle vents are sized based on winter conditions; at other times of the year, partially open windows may be required to avoid poor indoor air quality. However, there is no guidance provided in ADF on the area of opening that may be required, therefore this assessment is based on external noise ingress through closed windows and open trickle vents.

Based on a house not a flat

B.21 External levels for use of ADF System 1 are based on calculations according to the detailed method described in BS 8233, (equivalent to the method in BS EN 12354-3) [45] A typical small bedroom is considered. The *Technical housing standards – nationally described space standard* [46] indicates that a single bedroom should be at least 7.5 m^2. The glazed area is considered to 25% of the floor area, as described in SAP.

B.22 These dimensions represent unfavourable ratios between element performance and overall facade level difference, but worse case conditions may be four
between element performance and partial interna
following relationship, following the detailed metl

- $L_{2,\,glass} = L_{1,ff} - (R_w + C_{tr}) - 2$
- $L_{2,\,vent} = L_{1,\,ff} - (D_{n,e,w} + C_{tr}) + 5$ [for each vent]

$$L_2 = L_{1,ff} - R + 10\,Log\left(\frac{ST}{V}\right) + 11$$

$$L_2 = L_{1,ff} - D_{n,e} + 10\,Log\left(\frac{T}{V}\right) + 21$$

https://www.apexacoustics.co.uk/calculation-facade-sound-insulation/

Table B-2 Potential level differences associated with different ventilation Systems from ADF

Ventilation System from ADF	Cont. equiv. (L_{Aeq}) or events (L_{AFmax})	Level Difference, external free field level – internal reverberant level, dB	
		[redacted]	[redacted]
1, 2	L_{Aeq}	21	31
	L_{AFmax}	22	35
3 (with trickle vent)	L_{Aeq}	23	33
	L_{AFmax}	24	38
4 (no trickle vent)	L_{Aeq}	27	38
	L_{AFmax}	31	45

Table B-3 Summary of potential noise issues associated with ventilation strategies described in ADF

ADF System	External noise ingress considerations	Mechanical system noise considerations	Approximate guideline free-field external noise limits. [Note 1]
1 or 2	Noise ingress is likely to be defined by the performance of the background ventilators (trickle vents), windows and other façade elements. Note that use of System 1, relying on the use of open trickle vents without opening windows may give rise to poor indoor air quality in airtight dwellings outside the winter period.	For System 1, intermittent kitchen and bathroom fans should have suitable noise levels to meet the guidelines in Table 3-4. System 2 has no mechanical components.	With standard double glazing and two trickle vents: • ~$L_{Aeq,16h}$ 56 dB day • ~$L_{Aeq,8h}$ 51 dB night • L_{AFmax} not normally exceeding ~ 67 dB more than 10x per night With high performing acoustic glazing and two 'acoustic' trickle vents: • ~ $L_{Aeq,16h}$ 66 dB day • ~ $L_{Aeq,8h}$ 61 dB night • L_{AFmax} not normally exceeding ~ 80 dB more than 10x per night

Table B-3 Summary of potential noise issues associated with ventilation strategies described in ADF

ADF System	External noise ingress considerations	Mechanical system noise considerations	Approximate guideline free-field external noise limits. [Note 1]
3	Noise ingress is likely to be defined by the performance of the background ventilators (trickle vents), windows and other façade elements. ADF advises that: "*controllable background ventilators having a minimum equivalent area of 2,500 mm² should be fitted in each room, except wet rooms…*"	This could be a centralised or decentralised MEV system. Guideline levels are shown in Table 3-4. For a centralised system, the location of the fan is important for structure-borne and airborne noise. System noise may affect living rooms and bedrooms as well as the rooms in which the extract inlets are located i.e. wet rooms. For a decentralised system, there are individual fans extracting from each bathroom, toilet, kitchen and utility room. The noise effects on adjacent living rooms and bedrooms should be considered. [Note 2]	With standard double glazing and trickle vent: • ~$L_{Aeq,16h}$ 58 dB day • ~$L_{Aeq,8h}$ 53 dB night • L_{AFmax} not normally exceeding ~ 69 dB more than 10x per night With high performing acoustic glazing and an 'acoustic' trickle vent: • ~ $L_{Aeq,16h}$ 68 dB day • ~ $L_{Aeq,8h}$ 63 dB night • L_{AFmax} not normally exceeding ~ 83 dB more than 10x per night

Table B-3 Summary of potential noise issues associated with ventilation strategies described in ADF

ADF System	External noise ingress considerations	Mechanical system noise considerations	Approximate guideline free-field external noise limits. [Note 1]
4	No trickle vents required. Consider noise ingress through other facade elements.	MVHR is a centralised system ducted to supply outlets in living rooms and bedrooms as well as to extracts in wet rooms. Guideline levels are shown in Table 3-4. The unit location is important for structure-borne and airborne noise. Consider ducted noise, particularly to bedrooms. Consider also cross-talk sound transmission via ducts. [Note 2]	With standard double glazing and no trickle vent: • ~ $L_{Aeq,16h}$ 62 dB day • ~ $L_{Aeq,8h}$ 57 dB night • L_{AFmax} not normally exceeding ~76 dB more than 10x per night With high performing acoustic glazing: • ~ $L_{Aeq,16h}$ 73 dB day • ~ $L_{Aeq,8h}$ 68 dB night • L_{AFmax} not normally exceeding ~ 90 dB more than 10x per night N.B. With secondary glazing higher sound insulation may be achieved.

Appendix C

C Appendix C – sound insulation of a partially open window

THE BUILDING PERFORMANCE CENTRE
SCHOOL OF THE BUILT ENVIRONMENT
NAPIER UNIVERSITY

NANR116: 'OPEN/CLOSED WINDOW RESEARCH'

SOUND INSULATION THROUGH VENTILATED DOMESTIC WINDOWS

Term	Description	Configuration
A-1	Window A, outward opening casement - left hand side	
A-2	Window A, outward opening casement - right hand side	
A-3	Window A, top hung outward opening casements	
B	Window B, side swing reversible	
C-1	Window C, horizontal inward tilt	

International Journal of *Environmental Research and Public Health*
MDPI

Article

Differences between Outdoor and Indoor Sound Levels for Open, Tilted, and Closed Windows

Barbara Locher [1,†], André Piquerez [2], Manuel Habermacher [3], Martina Ragettli [2,4], Martin Röösli [2,4], Mark Brink [5], Christian Cajochen [6], Danielle Vienneau [2,4], Maria Foraster [2,4], Uwe Müller [7] and Jean Marc Wunderli [1,*]

BRITISH STANDARD
BS EN 12354-3:2000

Building acoustics — Estimation of acoustic performance of buildings from the performance of elements —

Part 3: Airborne sound insulation against outdoor sound

D.2 Small elements

These façade elements like air inlets show a large variety in construction details, which make it impossible to present generalized data.

For unsilenced air inlets, like openings or louvres, a global indication is given by treating the element as an opening with negligible sound reduction. This results in an element normalized level difference of:

$$D_{n,e} = -10 \lg \frac{S_{open}}{10} \qquad (D.1)$$

where

S_{open} is the area of the opening, in square metres.

Appendix B

Worked example

Table B-8 Consider noise levels at four different receptors across the example site

External free-field noise level	Receptor A	Receptor B	Receptor C	Receptor D
Daytime $L_{Aeq,16h}$, dB	53	59	64	72
Night-time $L_{Aeq,8h}$, dB	45	52	59	67
Ventilation design case Night-time L_{AFmax}, dB	63	69	78	83
Overheating design case Night-time L_{AFmax}, dB	72	77	87	94

Notes

Ventilation design case Night- time L_{AFmax} is the level that is not normally exceeded more than 10 times per night

Overheating design case Night- time L_{AFmax} is the level that is not normally exceeded.

Assessing L_{max} for residential developments: the AVO guide approach.
B Paxton, N Conlan, J Harvie-Clark A Chilton, D Trew. Proc IOA Vol 41 Pt.1 2019

Receptor	Summary of ventilation strategies
B	ADF System 3 (noting that System 1 may be feasible). Standard glazing and trickle vents with enhanced acoustic performance are required for ventilation – see discussion in Table B-11 and requirements in Table B-14. Detailed calculations presented (omitted from this worked example for brevity).

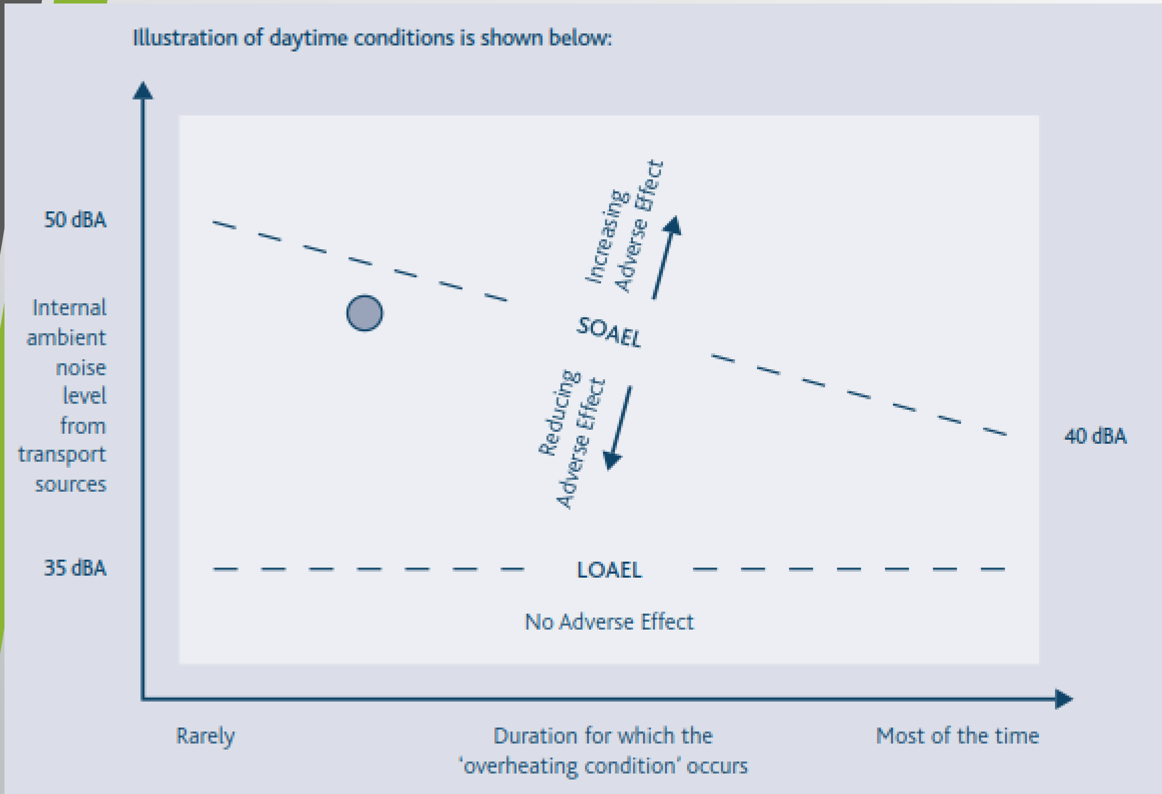
Table B-14 Summary of minimum element performance requirements and associated level differences achieved

Location	External free-field noise levels (dB)	Ventilation Condition				Overheating Condition
		Design	Element performances	Expected Outside-to-inside sound insulation (dB)	Expected internal ambient noise levels (dB)	
B	$L_{Aeq,16h}$ 59 $L_{Aeq,8h}$ 52 Vent D/C $L_{AF,max}$ 69 O'heat D/C L_{AFmax} 77	ADF Sys. 3	Glazing: 31 (-6) dB R_w (C_{tr}) e.g. 4/16/4 mm double glazing Trickle vent: 34 (-1) dB $D_{n,e,w}$ (C_{tr})	$L_{Aeq,T}$ 24 $L_{AF,max}$ 27	$L_{Aeq,16h}$ 35 $L_{Aeq,8h}$ 28 *D/C:* L_{AFmax} 42	

Table B-11 Worked example of Step 3 assessment – considering the effect of potential overheating mitigation strategies on the acoustic conditions – Receptor B **- Part 1 of 4**

External free-field noise level (dB)	Level 1 risk assessment (in line with Table 3-2)	Notes on overheating mitigation and requirement for Level 2 assessment	Level 2 assessment (in line with Table 3-3, with mitigation)
Daytime $L_{Aeq,16h}$ 59 **Night-time** $L_{Aeq,8h}$ 52 **Overheating design case** L_{AFmax} 77	Medium	**North east elevations, all room types** The overheating assessment indicates a low risk of overheating. The anticipated internal levels with a partially open window (13 dB attenuation) to control overheating would be 46 dB during the day and 39 dB at night, with overheating design case L_{AFmax} levels up to 64 dB. Considering these levels on the AVO diagrams below, these levels are below the "SOAEL" level, and below a level at which noise causes a material change in behaviour in Table 3-3. They are considered to be suitable for occupants given the relatively low overheating risk, and hence limited periods of time that windows are required to be open to mitigate overheating, especially during the night-time period.	Increasing likelihood of adverse impact, but for limited duration. Considered to be below a significant adverse effect for this combination of level and duration.

AVO Diagrams



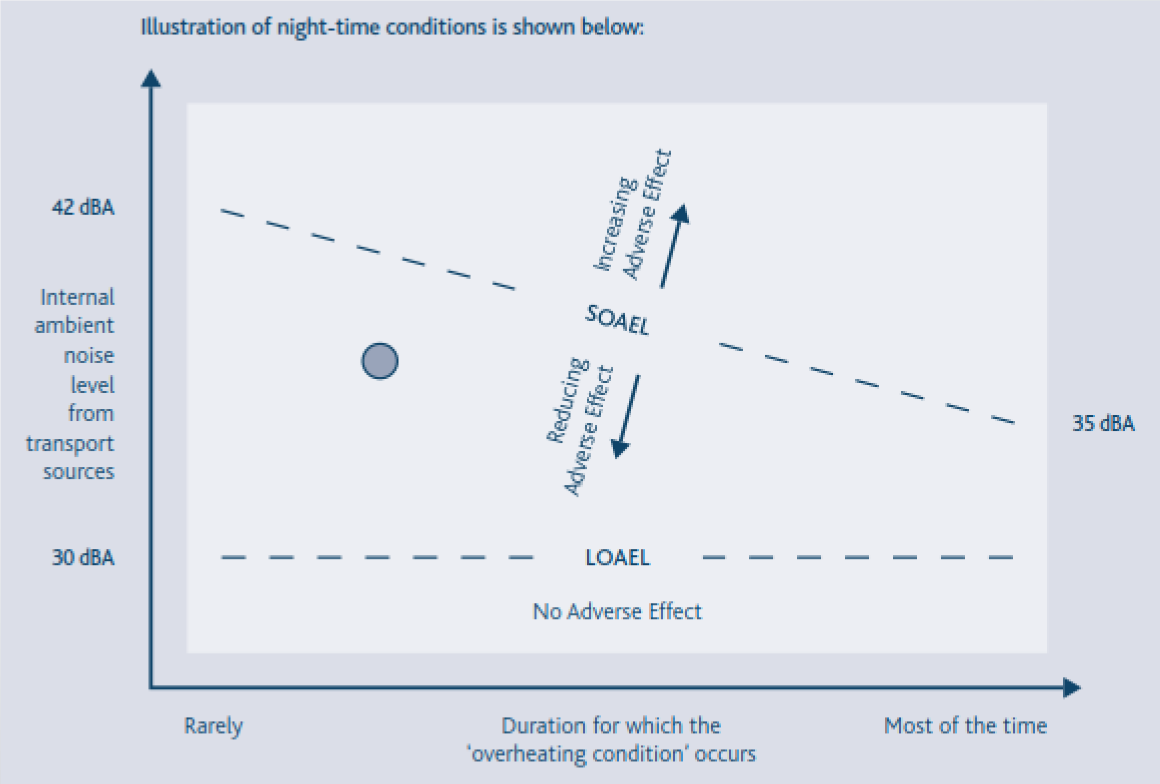
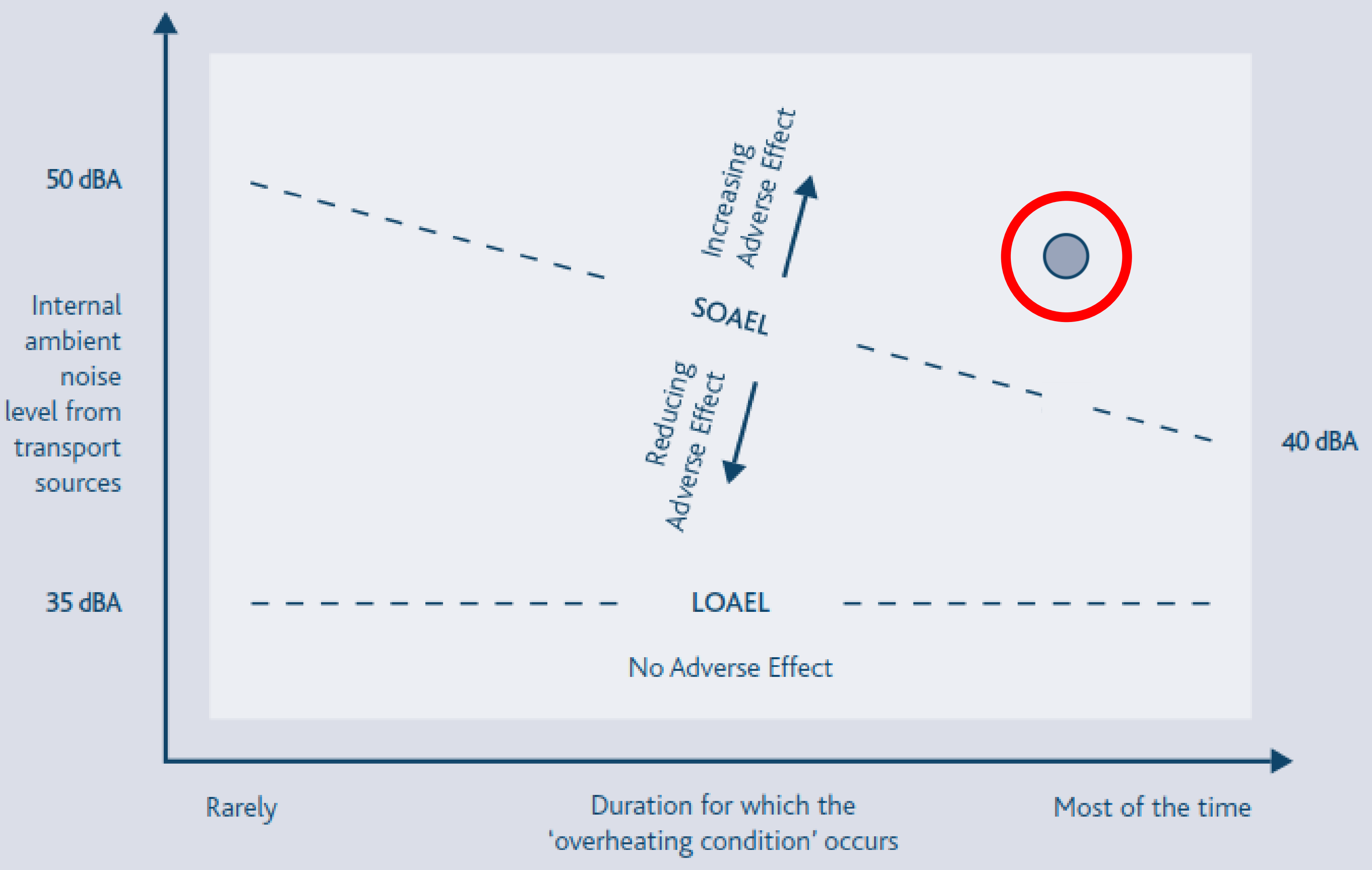


Table B-11 Worked example of Step 3 assessment – considering the effect of potential overheating mitigation strategies on the acoustic conditions – Receptor B - **Part 2 of 4**

External free-field noise level (dB)	Level 1 risk assessment (in line with Table 3-2)	Notes on overheating mitigation and requirement for Level 2 assessment	Level 2 assessment (in line with Table 3-3, with mitigation)
Daytime $L_{Aeq,16h}$ 59 **Night-time** $L_{Aeq,8h}$ 52 **Overheating design case** L_{AFmax} 77	Medium	**South west elevations, living rooms** The overheating assessment indicates a high risk of overheating. **Scenario 1 – Mitigation of noise** Standard opening windows are not considered to be a suitable solution for SW elevations because of the higher overheating risk meaning that open windows are required more often and for longer periods, including during the night-time. These elevations therefore incorporate measures to mitigating the noise impact. Living rooms have balconies that enable staggered openings into the balcony area, containing sound absorption, so that opening windows are protected from direct noise impact. Detailed calculations demonstrate that the balcony and opening window arrangement achieve a level difference of 17 dB for the incident noise spectrum, while providing sufficient open area to enable control of overheating (the acoustician should cross-reference assumptions regarding open areas used in the overheating assessment). Thus, while mitigating overheating, the internal noise level is calculated to be 42 dBA during the daytime. This level is considered to be below a SOAEL on the AVO Diagram (see AVO Diagram below), and therefore considered suitable for the number of occasions for which open windows are required.	Increasing likelihood of adverse impact, but for limited duration. Considered to be below a significant adverse effect for this combination of level and duration.

Scenario 1 – Mitigation of noise

Illustration of daytime conditions is shown below:



Scenario 2 – Mitigation of overheating

Illustration of daytime conditions is shown below:

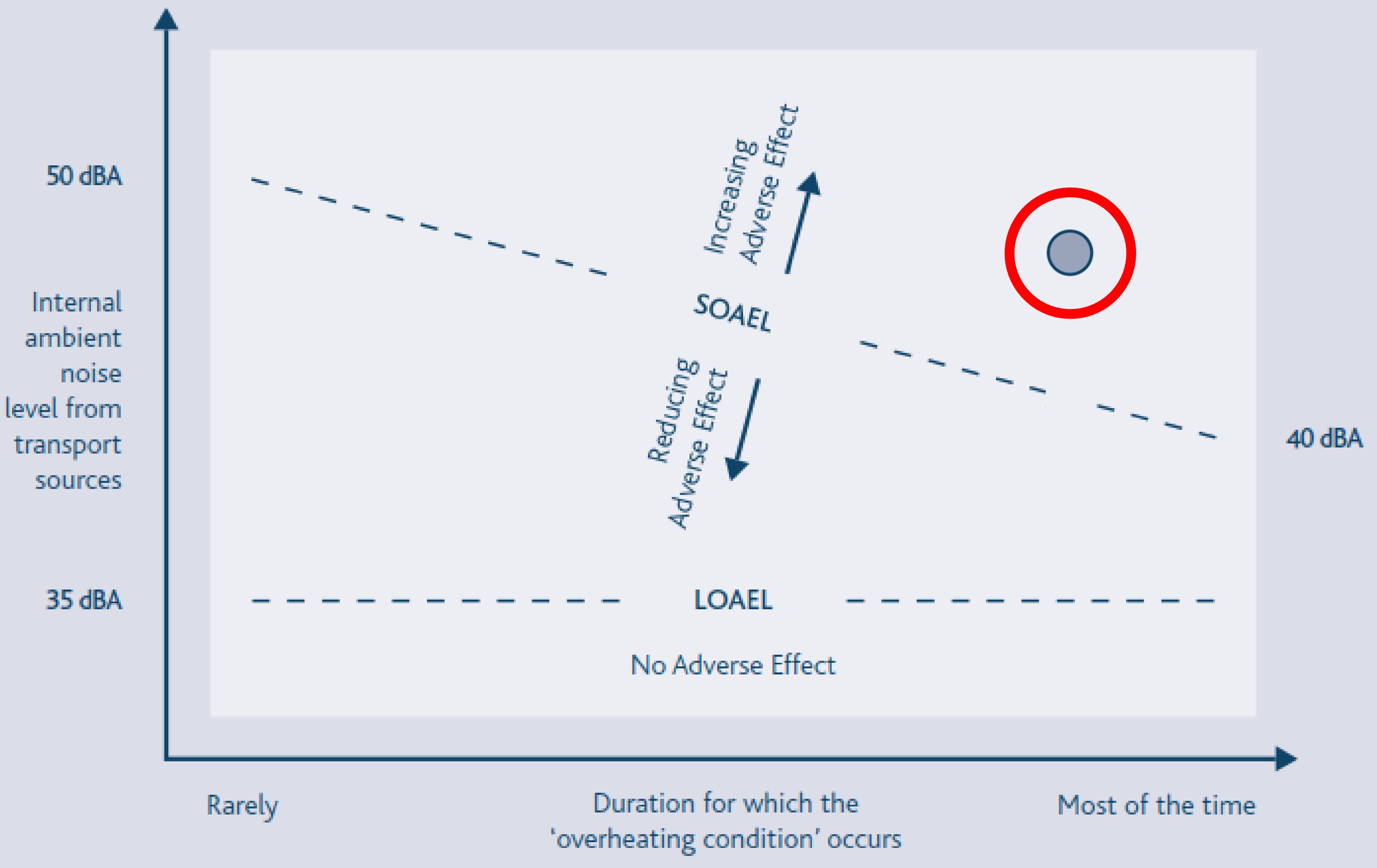


Table B-11 Worked example of Step 3 assessment – considering the effect of potential overheating mitigation strategies on the acoustic conditions – Receptor B **- Part 4 of 4**

External free-field noise level (dB)	Level 1 risk assessment (in line with Table 3-2)	Notes on overheating mitigation and requirement for Level 2 assessment	Level 2 assessment (in line with Table 3-3, with mitigation)
Daytime $L_{Aeq,16h}$ 59 Night-time $L_{Aeq,8h}$ 52 Overheating design case L_{AFmax} 77	Medium	**South west elevations, bedrooms** The overheating assessment indicates a high risk of overheating. Standard opening windows are not considered to be a suitable solution for SW elevations because the higher risk of overheating means that windows are required to be open more often. These elevations incorporate measures to mitigating the noise impact. Bedrooms have plenum windows that are calculated to provide a level difference between outside and in of 19 dB for road traffic noise, based on the measured incident noise spectra. An attenuation of 22 dB is calculated for the typical spectrum associated with L_{AFmax} noise from events. The overheating assessment confirms that the plenum window dimensions are adequate to suitably mitigate overheating (the acoustician should cross-reference assumptions used in the overheating assessment). Thus, while mitigating overheating, an internal noise level of $L_{Aeq,8h}$ 33 dB is calculated (detailed calculations presented in accordance with the detailed method in BS 8233). This value is not more than 5 dB above the lowest category according to Table 3-3, and therefore may be considered "Reasonable" according to ProPG. This sits comfortably on the AVO Diagram shown below. Maximum noise levels from events are calculated to be up to 55 dB L_{AFmax} for	Increasing likelihood of adverse impact, on the basis of Overheating D/C L_{AFmax} level.

Illustration of night-time conditions is shown below:

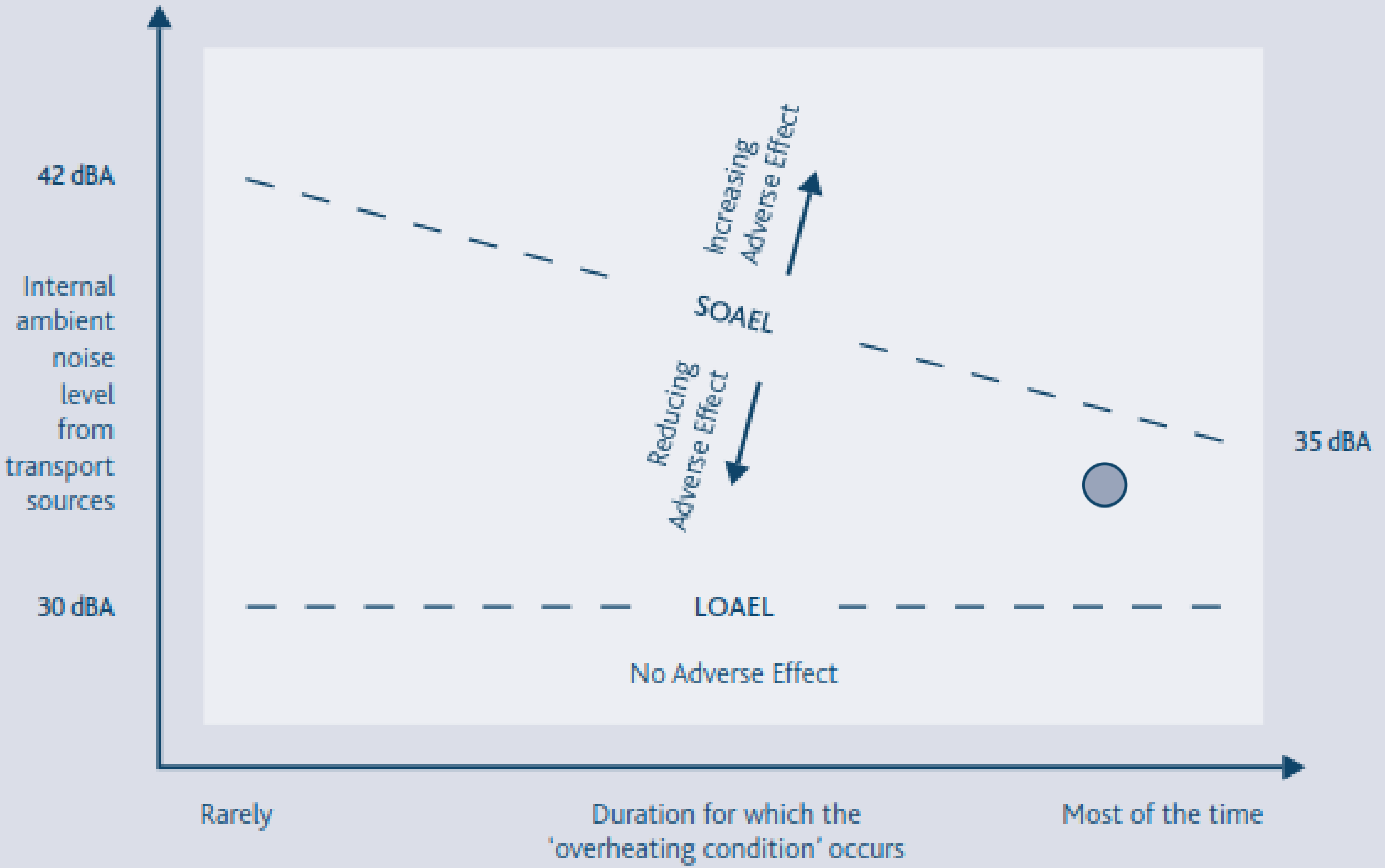
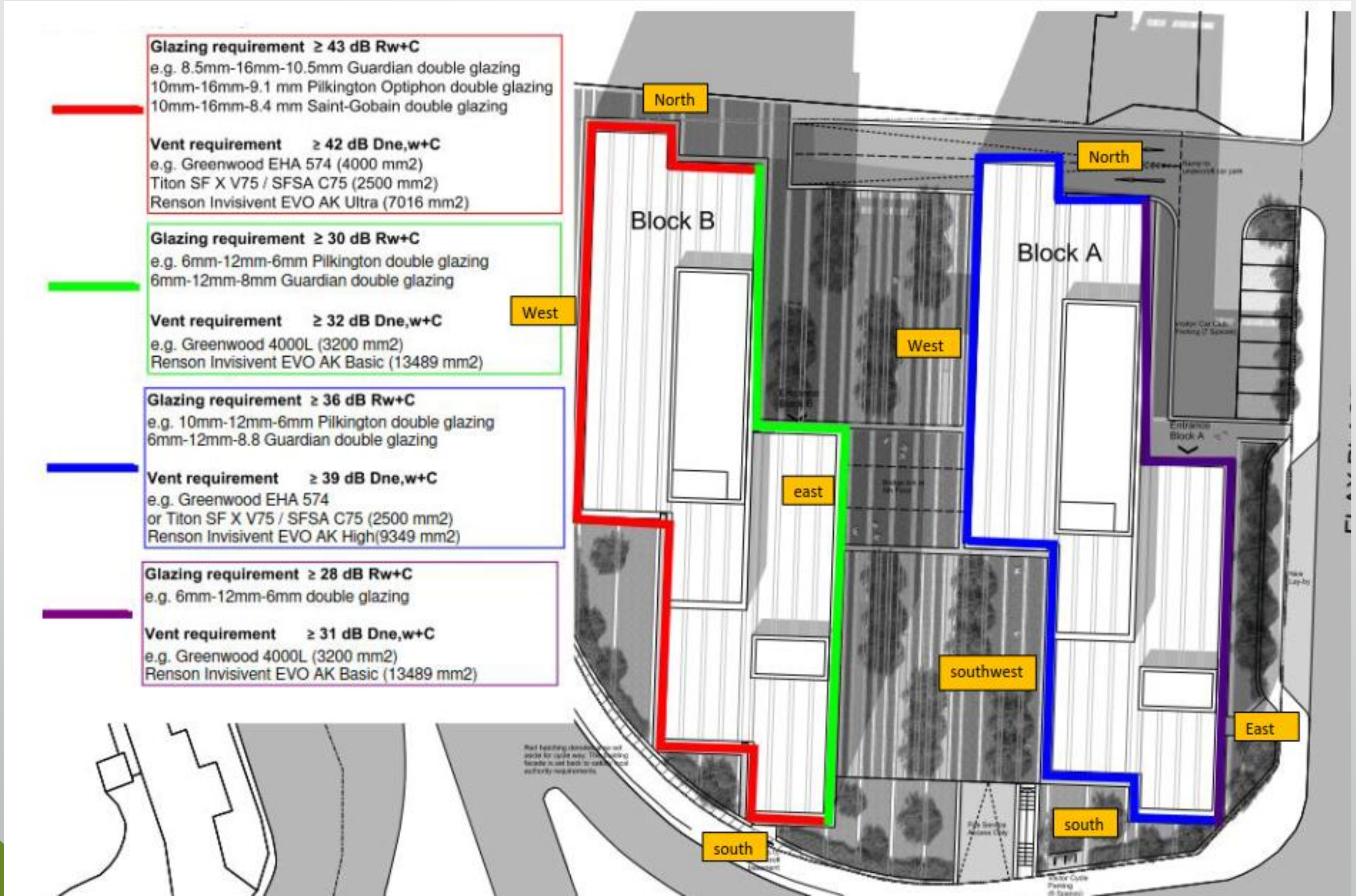


Table B-14 Summary of minimum element performance requirements and associated level differences achieved

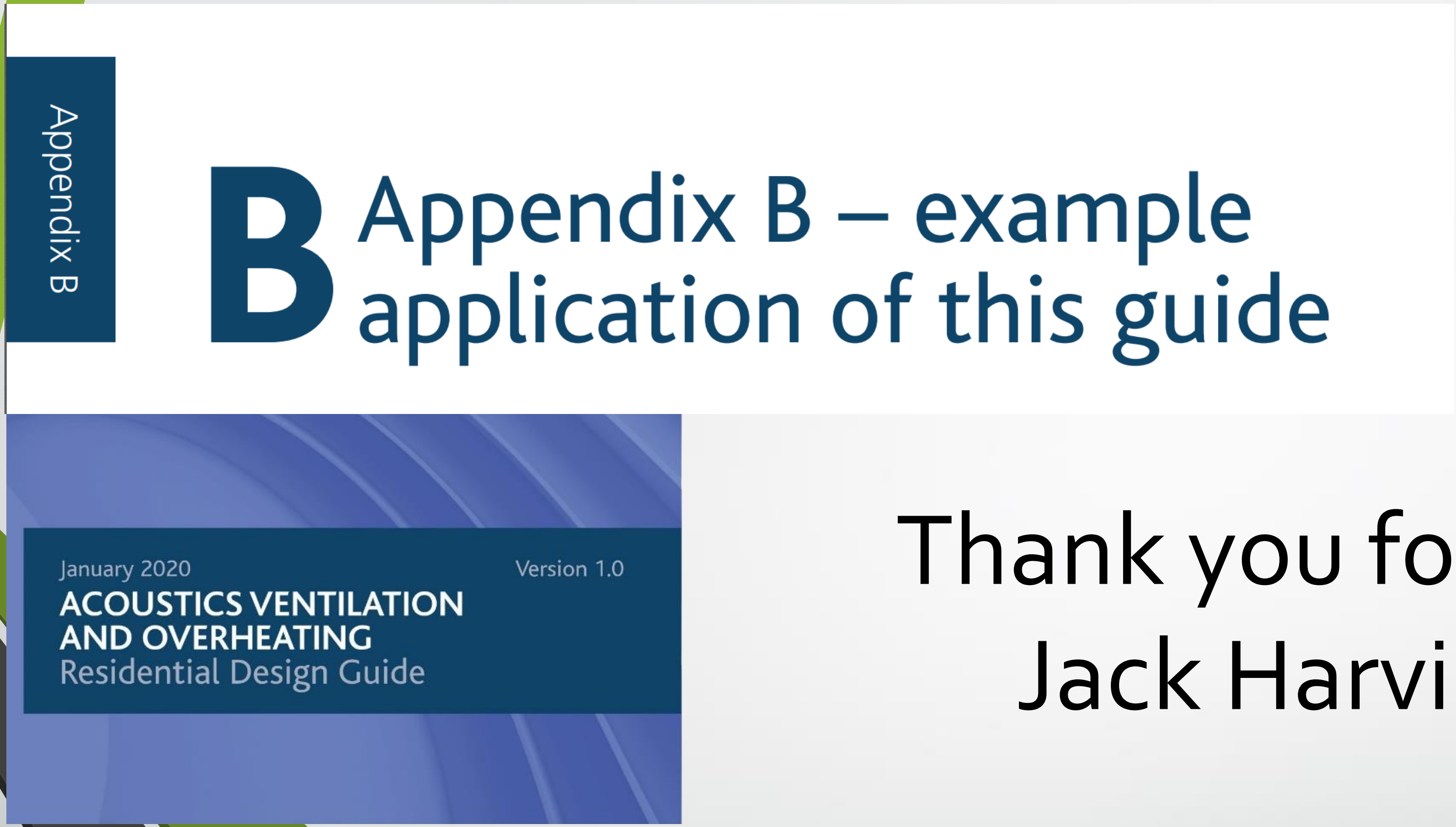
Location	External free-field noise levels (dB)	Ventilation Condition				Overheating Condition							
		Design	Element performances	Expected Outside-to-inside sound insulation (dB)	Expected internal ambient noise levels (dB)	Orientation	Room Type	Design	Element performances	Expected Outside-to-inside sound insulation (dB)	Expected internal ambient noise levels (dB)	Occurrence	Level 2 Assessment
B	$L_{Aeq,16h}$ 59 $L_{Aeq,8h}$ 52 Vent D/C $L_{AF,max}$ 69 O'heat D/C L_{AFmax} 77	ADF Sys. 3	Glazing: 31 (-6) dB R_w (C_{tr}) e.g. 4/16/4 mm double glazing Trickle vent: 34 (-1) dB $D_{n,e,w}$ (C_{tr})	$L_{Aeq,T}$ 24 $L_{AF,max}$ 27	$L_{Aeq,16h}$ 35 $L_{Aeq,8h}$ 28 *D/C:* L_{AFmax} 42	NE	B&L	Standard opening windows	See Table B-5	$L_{Aeq,T}$ 13 $L_{AF,max}$ 13	$L_{Aeq,16h}$ 46 $L_{Aeq,8h}$ 39 *D/C:* L_{AFmax} 64	Rarely	Increasing likelihood of adverse impact, but for limited duration. Below a significant adverse effect.
						SW	L Sc1	Open windows with sound att. balconies	See Table B-5	$L_{Aeq,T}$ 17	$L_{Aeq,16h}$ 42	Often	Low end of Increasing likelihood of adverse impact. Below a significant adverse effect.
							L Sc2	Standard opening windows	See Table B-5	$L_{Aeq,T}$ 13	$L_{Aeq,16h}$ 46	Occasionally	Increasing likelihood of adverse impact, but for limited duration. Below a significant adverse effect.
						SW	B	Plenum windows	See Table B-5	$L_{Aeq,T}$ 19 $L_{AF,max}$ 22	$L_{Aeq,16h}$ 40 $L_{Aeq,8h}$ 33 *D/C:* L_{AFmax} 55	Often	Increasing likelihood of adverse impact. Below a significant adverse effect.

Example façade mark up - ventilation



Conclusions

- Assessment is complicated
- Solutions are complex
- Expect variable performance requirements
- Embrace the design team!
- Early engagement for integrated, passive solutions
- Need to balance good IEQ (comfort) with energy use
- Develop context-specific approach and solutions
- Today we collaborate. Tomorrow we compete.
  Can we hold common ground?



Appendix B

B Appendix B – example application of this guide

January 2020 Version 1.0

ACOUSTICS VENTILATION AND OVERHEATING

Residential Design Guide

ANC ACOUSTICS & NOISE CONSULTANTS

Thank you for listening

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