Acoustics, Ventilation and Overheating Residential Design Guide

Jack Harvie-Clark

Anthony Chilton

Draft: Consultation runs until 12th May
Overview

• Introduction, context – why do we need the AVO guide?
• AVO Guidance – external noise sources
• AVO Guidance – mechanical services noise
• Integrated design solutions & case studies
• Design process
Why do we need a Guide?

- Façade sound insulation – Planning
- Ventilation strategy – later, Building Control
- Overheating assessment – variable assumptions
- Noise from domestic mechanical ventilation

“85 % of planning applications assume – windows open for the overheating assessment, windows closed for the acoustic assessment”

Using planning conditions to improve indoor environmental quality (IEQ) of new residential developments

Context for noise: planning

Noise Policy Statement for England (NPSE)

- Adverse effects
- Mitigate & minimise above LOAEL
  *Lowest Observable Adverse Effect Level*
- Avoid SOAEL
  *Significant Observable Adverse Effect Level*

Dose response relationship
Para. 2.34:

... design the accommodation so that it provides good standards of acoustics, ventilation and thermal comfort ...
ANC Acoustics, Ventilation, Overheating Group

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Gary Timmins  bre  Stephen Turner
Ian MacArthur  Stephen Turner Acoustics Ltd  Nick Conlan
AVO Guide - 4 distinct areas for guidance

1. Noise from External Transport Sources
2. BS 8233:2014
3. Noise from Mechanical Services
4. Overheating Condition
External Noise – ADF Ventilation Condition

- Average values for daytime and night-time periods
- AVO Guide clarifies that BS 8233 values...
  - Do apply for ADF whole dwelling ventilation rate (all year round)
  - Do not apply for ADF purge situation (occasional)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Location</th>
<th>07:00 to 23:00</th>
<th>23:00 to 07:00</th>
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<tbody>
<tr>
<td>Resting</td>
<td>Living room</td>
<td>35 dB $L_{Aeq,16\text{hour}}$</td>
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</tr>
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<td>Dining room/area</td>
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<td>—</td>
</tr>
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<td>Sleeping (daytime resting)</td>
<td>Bedroom</td>
<td>35 dB $L_{Aeq,16\text{hour}}$</td>
<td>30 dB $L_{Aeq,8\text{hour}}$</td>
</tr>
</tbody>
</table>
Achieving BS 8233 – ADF systems

• Sound insulation of the façade is affected by the nature of the ventilation openings.

<table>
<thead>
<tr>
<th>AD-F System</th>
<th>Typical constraints for external night time noise environment, dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2 (trickle vents)</td>
<td>53 dB</td>
</tr>
<tr>
<td>3 (MEV + trickle vents)</td>
<td>63 dB</td>
</tr>
<tr>
<td>4 (MVHR)</td>
<td>Limited by glazing</td>
</tr>
</tbody>
</table>
AVO Guide - 4 distinct areas for guidance

<table>
<thead>
<tr>
<th>Noise from External Transport Sources</th>
<th>Noise from Mechanical Services</th>
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<td>ADF Ventilation Condition</td>
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<tr>
<td>Overheating Condition</td>
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External Noise – Overheating Condition

• No existing guidance, limited scientific basis.

• **Daytime**
  • Interference with activities (speech)

• **Night time**
  • Sleep disturbance
## Risk category based on noise level

<table>
<thead>
<tr>
<th>Internal ambient noise level (Overheating situation)</th>
<th>AVO Guide Risk category</th>
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<tbody>
<tr>
<td>$L_{A_{eq,T}}$ during 07:00 – 23:00</td>
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<td>$\leq 35 \text{ dB}$</td>
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</tr>
<tr>
<td>$&gt; 40 \text{ dB}$ and $\leq 50 \text{ dB}$</td>
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</tr>
<tr>
<td>$&gt; 50 \text{ dB}$</td>
<td>$&gt; 43 \text{ dB}$</td>
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</tbody>
</table>

- Speech communication significantly affected
- “Sizeable proportion of the population is highly annoyed and sleep-disturbed”
Adverse Effect from Noise

- Adverse effect on occupants depends on:
  - Noise level
  - Frequency and duration for which windows need to be open
- Need information from thermal model.
- Adverse noise effect can be mitigated by thermal gains.
- Collaborative design process.
Two Level Assessment Procedure

Level 1 Assessment
Assess risk of adverse effect in accordance with guidance in Table 3-2

Low risk

Present Level 1 assessment to include the following minimum information:
- Details of external noise levels and method by which they have been determined.

High risk

Medium risk

Present Level 1 assessment to include the following minimum information:
- Details of external noise levels and method by which they have been determined
- Description of provisions for the control of overheating (e.g. opening windows, attenuated vents, mechanical cooling)
- Assessment of risk of adverse effect on occupants.

Level 2 Assessment
Assess risk of adverse effect in accordance with guidance in Table 3-3

Optional
Two Level Assessment Procedure

Level 1 – Based on external Levels

- Simple assessment that will be sufficient for many sites.
- Assumes level difference of 12dB for a window.
- High risk therefore corresponds to external levels of:
  - > 62dB (Daytime)
  - > 55dB (Night-time)

- If Level 1 indicates **high risk** then a more detailed **Level 2** assessment is recommended.
Two Level Assessment Procedure

Level 2 – Based on internal Levels

- Use the actual sound reduction of the façade.
- Evaluate adverse effect based on calculated internal noise levels.

<table>
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<tr>
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<th>AVO Guide Risk category</th>
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</thead>
<tbody>
<tr>
<td>$L_{A_{eq,T}}$ during 07:00 – 23:00</td>
<td>$L_{A_{eq,B}}$ during 23:00 – 07:00</td>
</tr>
<tr>
<td>≤ 35 dB</td>
<td>≤ 30 dB</td>
</tr>
<tr>
<td>&gt; 35 dB and ≤ 40 dB</td>
<td>&gt; 30 dB and ≤ 35 dB</td>
</tr>
<tr>
<td>&gt; 40 dB and ≤ 50 dB</td>
<td>&gt; 35 dB and ≤ 43 dB</td>
</tr>
<tr>
<td>&gt; 50 dB</td>
<td>&gt; 43 dB</td>
</tr>
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</table>

- Allows for overheating solutions that provide more sound insulation than a basic open window (more later).
AVO Guide - 4 distinct areas for guidance

<table>
<thead>
<tr>
<th>ADF Ventilation Condition</th>
<th>Noise from External Transport Sources</th>
<th>Noise from Mechanical Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 BS 8233:2014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guidance on sound insulation and noise reduction for buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Overheating Condition</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

1. BS 8233:2014

Guidance on sound insulation and noise reduction for buildings
# Ventilation - mechanical services noise

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Approved Document F $\text{dB} L_{Aeq,T}$</th>
<th>CIBSE Guide A, Table 1.5 $\text{dB} L_{Aeq,T}$</th>
<th>NR</th>
<th>Sound control for homes $\text{dB} L_{Aeq,T}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom</td>
<td>30</td>
<td>30</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Living Room</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Dining Room</td>
<td></td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Bathroom / WC</td>
<td></td>
<td></td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>45-50</td>
<td>40-45</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

## Ventilation condition

- **Whole dwelling**
- **Extract ventilation**
Table 5.4. Sound levels in dwellings due to building service equipment. 
Class limits.(1)

<table>
<thead>
<tr>
<th>Type of space and sources (2)</th>
<th>Class A (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
<th>Class B (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
<th>Class C (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
<th>Class D (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
<th>Class E (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
<th>Class F (L_{eq} \text{ or } L_{\text{max}}) (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In dwellings due to ventilation / heating / cooling installation (L_{eq}^i)</td>
<td>(\leq 20)</td>
<td>(\leq 24)</td>
<td>(\leq 28)</td>
<td>(\leq 32)</td>
<td>(\leq 36)</td>
<td>(\leq 40)</td>
</tr>
</tbody>
</table>

COST TU 0901, Building acoustics throughout Europe Volume 1: Towards a common framework in building acoustics throughout Europe, [download here](#)
Kurnitski et al, 2007: 102 homes

Other studies

Hasselaar, 2008, Netherlands: 500 homes
  Noise limits occupiers’ use of fan settings
Hady et al, 2008, Denmark, 100 homes
  Set point too noisy, operated lower with health effects
Balvers et al, Netherlands 2012, 300 homes
  >30 dB(A) at set point in 86 % of homes
Brown & Gorgolewski, 2015, Canada, 165 homes
  HVAC noise causes dissatisfaction and switching off of fans
The end result was that nearly all of the 13 occupants interviewed by the team across the sites had turned off their ventilation systems, finding them too noisy, especially at night.

If systems are turned off, they are not doing their job. The air quality in the property will be compromised, with potentially serious consequences for the health of occupants.
Potential requirements

30 dB(A) likely to be widely unacceptable

Optimal limit:
Mech services noise ≤ 24 dB(A) in bedrooms

EPSRC bid with Salford, Oxford Brookes & Glasgow Universities

How loud is too loud? Noise from domestic mechanical ventilation systems, J Harvie-Clark, N Conlan;
38th AIVC, 6th TightVent & 4th Venticool Conference.
Ventilating healthy low-energy buildings, September 2017, Nottingham, UK
Mechanical services noise

<table>
<thead>
<tr>
<th>Condition</th>
<th>Desirable Indoor Ambient Noise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole dwelling ventilation</td>
<td>Approved Document F</td>
</tr>
<tr>
<td>Extract ventilation</td>
<td>CIBSE Guide A Table 1.5, or Sound Control for Homes</td>
</tr>
<tr>
<td>Purge ventilation</td>
<td>None</td>
</tr>
<tr>
<td>Overheating</td>
<td>CIBSE Guide A Table 1.5 with reference to Section 1.10.10</td>
</tr>
</tbody>
</table>

Section 1.10.10
A range of +/- 5dB may be acceptable depending on the particular situation

<table>
<thead>
<tr>
<th>Room Type</th>
<th>CIBSE Guide A, Table 1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Type</td>
<td>dB $L_{\text{Aeq, T}}$</td>
</tr>
<tr>
<td>Bedroom</td>
<td>30</td>
</tr>
<tr>
<td>Living Room</td>
<td>35</td>
</tr>
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<td>45-50</td>
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</table>
## Services noise - overheating control

<table>
<thead>
<tr>
<th>Means of cooling</th>
<th>Description</th>
<th>External noise</th>
<th>Mech system noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive ventilative cooling</td>
<td>Open windows or vents</td>
<td>✓</td>
<td>N/A (unless ceiling fans are used)</td>
</tr>
<tr>
<td>Mechanical ventilative cooling</td>
<td>External ambient air, mechanically driven. e.g. independent system or boost-mode for MVHR system</td>
<td>✗</td>
<td>Air-flow significantly higher than ADF whole dwelling. Increase fan noise &amp; regenerated noise at grilles</td>
</tr>
<tr>
<td>Mechanically cooled air</td>
<td>“air-conditioning” or “comfort cooling” Integrated with MVHR?</td>
<td>✗</td>
<td>Indoor units (fan-coils, cassettes etc.) Outdoor units also generate noise.</td>
</tr>
</tbody>
</table>
Design solutions

• Passive options
• Case studies
Options for passive ventilative cooling

- Standard Windows
- Balconies
- Attenuated Windows
- Attenuated Vents

Outside-Inside Level Difference [dB]
Sound attenuating balconies

Methods of controlling noise levels and overheating in residential buildings.
N Conlan, J Harvie-Clark, 24th Int. Congress on Sound & Vibration, 2017, London
Sound attenuating windows

http://www2.mst.dk/Udgiv/publikationer/2017/05/978-87-93529-98-4.pdf
Sound attenuating vents

https://hal.archives-ouvertes.fr/hal-00810623/document
Case studies

- NW Cambridge
- St. John’s Hill
NW Cambridge

RH Partnership, AECOM
Attenuated vents: NW Cambridge
St John’s Hill, Clapham

Hawkins Brown Architects, Max Fordham MEP
St John’s Hill, Clapham
External Level
60-65dBA
at Night

30 -35dB Reduction
Windows Closed,
Trickle Vents Open

Internal Level
30 dBA

Table 4  Indoor ambient noise levels for dwellings  BS 8233

<table>
<thead>
<tr>
<th>Activity</th>
<th>Location</th>
<th>07:00 to 23:00</th>
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<tr>
<td>Resting</td>
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<td>Sleeping (daytime resting)</td>
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</table>
External Level 60-65dBA at Night

12 dB Reduction Window Open

Internal Level > 48 dBA

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</table>
External Level
60-65dBA at Night

24 - 27 dB Reduction
Acoustic Vent Open

Internal Level
~ 38 dBA

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Design Process
Integrated design

• Good Acoustic Design
• London Plan Policy 5.9

Major development proposals should reduce potential overheating & reliance on air conditioning systems & demonstrate this in accordance with the cooling hierarchy:

• 1 Minimise internal heat generation ...
• 2 Reduce .. heat entering a building ...
• 3 Exposed thermal mass and high ceilings
• 4 Passive ventilation
• 5 Mechanical ventilation
• 6 Active cooling systems

https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan/london-plan-chapter-five-londons-response/ poli-8
Overheating

TM59 defines prediction methodology:
Dynamic thermal modelling

**Model inputs**
Building location & orientation
Elevational details
Internal / external shading
Internal gains
Thermal mass
Room types
**Opening windows / doors**
**Mechanical systems**
Occupancy profiles
Weather files for site
Typical activities of the acoustic designer:

<table>
<thead>
<tr>
<th>Gather Information</th>
<th>Noise</th>
<th>Noise &amp; Ventilation</th>
<th>Noise &amp; Overheating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Quantify noise levels affecting the site by means of survey.</strong></td>
<td><strong>Consult with design team on initial proposals for ventilation.</strong> Establish which ADF template system is proposed.</td>
<td><strong>Consult with design team to establish basis of overheating analysis and related design considerations.</strong></td>
</tr>
<tr>
<td>Assess</td>
<td><strong>Assess variability of noise across the proposed development.</strong> <strong>Assess variability of noise with time.</strong></td>
<td><strong>Assess effect of ventilation strategy on noise levels.</strong> <strong>Assess which ADF template systems are likely to be viable.</strong></td>
<td><strong>Assess effect of overheating control strategy on noise levels.</strong> <strong>Assess where open windows are likely to be viable means of controlling overheating.</strong></td>
</tr>
<tr>
<td>Advise</td>
<td><strong>Advise noise levels for good health and wellbeing.</strong></td>
<td><strong>Advise acoustic requirements for different ventilation systems.</strong> <strong>Advise noise control for mechanical systems.</strong></td>
<td><strong>Advise risk of adverse noise effect with open windows.</strong> <strong>Advise areas where alternative means of controlling overheating should be developed.</strong></td>
</tr>
</tbody>
</table>

Iterative design development may be necessary.
Gather Information

**Noise**
- Quantify noise levels affecting the site by means of survey.

**Noise & Ventilation**
- Consult with design team on initial proposals for ventilation.
- Establish which ADF template system is proposed.

**Noise & Overheating**
- Consult with design team to establish basis of overheating analysis and related design considerations.

Assess variability of noise

Assess effect of ventilation strategy

Assess effect of overheating control
Assess variability of noise across the proposed development.

Assess variability of noise with time.

Assess effect of ventilation strategy on noise levels.

Assess which ADF template systems are likely to be viable.

Assess effect of overheating control strategy on noise levels.

Assess where open windows are likely to be viable means of controlling overheating.

Advise noise levels for good health and wellbeing.

Advise acoustic requirements for different ventilation systems.

Advise noise control for mechanical systems.

Advise risk of adverse noise effect with open windows.

Advise areas where alternative means of controlling overheating should be developed.

Iterative design development may be necessary.
Conclusions

• *AVO Guide* provides method for integrated design of acoustics with ventilation and thermal comfort

• Embrace your acoustician!

• Early engagement required to enable integrated, passive solutions

• Failure to engage early likely to result to mech cooling solutions

• Need to balance good IEQ with energy use

• Expect variable performance requirements

• Develop context-specific approach and solutions
Thank you for listening

Download the AVO Guide and respond to consultation: 
www.theanc.co.uk/avog

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a.chilton@maxfordham.com

More information:
Apex Acoustics: https://goo.gl/oDX5fu
Max Fordham Acoustics: https://goo.gl/GrGAJH