# Cutting to the chase on overheating, ventilation and the demonstration of acoustic compliance

Verifying the performance of façades that require acoustic treatment is complex, so in this article, Tony Higgins discusses 'some of the issues' with guidance and practice, and concludes that what is needed is a simple endorsed method, ideally aligned to data that is already available.

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Since the implementation of Building Regulations and the guidance contained in the Approved Documents (AD) (https://www.gov.uk/government/collections/approved-documents), regulation of building control has undergone many positive changes.

Homes are now constructed in a safe and sustainable manner, reflect modern standards of expectation and are generally safer. The Building Regulations and the ADs cover everything from specifications on basic structures, fire safety and provision of hot water, to conservation of fuel and power, electrical safety, drainage, materials and workmanship. The list is comprehensive and tries to ensure that building subject to the regulations are safe and sustainable homes fit for the 21stcentury.

It should come as no surprise that such a comprehensive system includes measures to control the transmission of noise internally (Approved Document E – ADE) or that guidance is provided to ensure buildings are adequately ventilated (Approved Document F – ADF) and protected from Overheating (Approved Document O – ADO). It is the ventilation and overheating requirements that have caused acousticians some concern, as the requirement to properly ventilate buildings can conflict with the requirement to prevent the ingress of excess environmental noise.

As might be apparent, this creates significant opportunity for opposing requirements to frustrate development. The remainder of this article will summarise those distinctions and (hopefully) provide some insight into how they may be addressed.

In the July/August 2021 issue of Acoustics Bulletin (page 52), Colling Et al. provided a summary of the 'new' Acoustic Ventilation Overheating Guidance (AVOG) that provided a potential way forward to address the increasingly complex interaction between conflicting requirements.

Whilst the AVOG was a welcome clarification to a confusing situation, the implementation of that guidance is still fraught with difficulties, not least because of the emphasis placed on the planning process not to permit development that is unsustainable or 'unacceptable' in acoustic terms.

## Planning and noise

The planning process grants consent for new development based on the policies set out by government in the National Planning Policy Framework (https://tinyurl.com/NPPFandlocalplanning) and local planning policy. Local planning policy and local plans have strategic elements that identify land suitable for particular types of development, residential, industrial, commercial, recreational etc. The local planning authorities 'expect' applications to be submitted that reference those strategic needs. In such cases, planning consent is often a streamlined process with fewer potential barriers to approval.

However, other applications that are not 'in accordance with' the approved strategic plans may still be acceptable if the application can demonstrate appropriate planning merit so that on balance approvals can be obtained. In these cases, there may be constraining factors on the developments that need to be addressed during the planning process, these may include noise controls such as requirements for design and orientation of buildings (layout), barriers, or restrictions on the façade insulation in the form of specified glazing, and other controls to prevent occupiers being exposed to excess noise.

Planning conditions have historically identified a need for glazing with a specific sound reduction requirement (Rw) that protects the occupiers to a standard (acceptable to planning).

The standards used normally link to World Health Organization 1999 guidelines on Community Noise for daytime and nighttime noise, and BS 8233:2014 Guidance on sound insulation and noise reduction for buildings. Both standards refer to a nighttime of <30 dB $L_{Aeq,8hour}$, and 35 dB $L_{Aeq,16hour}$ for daytime. BS8233:2014 Table 4 provides additional notes as follows:

NOTE 5
If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level.

If applicable, any room should have adequate ventilation (e.g. trickle ventilators should be open) during assessment.

NOTE 6
Attention is drawn to the Building Regulations [30, 31, 32].

NOTE 7
Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.

This is further endorsed by the Planning Practice Guidance on Noise (https://www.gov.uk/guidance/noise--2) which advises on the factors that influence when noise is of concern and in particular:

More specific factors to consider when relevant include:

- whether any adverse internal effects can be completely removed by closing windows and, in the case of new residential development, if the proposed mitigation relies on windows being kept closed most of the time (and the effect this may have on living conditions). In both cases a suitable alternative means of ventilation is likely to be necessary. Further information on ventilation can be found in the Building Regulations.' https://www.gov.uk/government/publications/ventilation-approved-document-f

The use of a ProPG approach (https://www.ioa.org.uk/publications/propg) to ensure that sensitive façades' exposure to noise is minimised is a clear first step. Layout of developments, where buildings protect amenity spaces and sensitive façades to provide good quality, low-noise, amenity spaces and low impacts at the façades of noise sensitive rooms, is standard practice but this approach often leads to one façade being significantly exposed to noise, and that façade is normally acoustically treated to ensure that internal levels are maintained appropriately. While this is clearly in line with national guidance and avoids sterilising potential sites unnecessarily, it does create problems with maintaining appropriate internal noise levels and comfort inside affected rooms.

The degree (and type) of mitigation required will be dictated by the noise source type, for example, road traffic, rail noise, aircraft noise, industrial/commercial noise, or other. In all cases part of the solution is enhancing glazing, a specification for sound reduction is normally coupled with passive or active ventilation requirements to positively demonstrate that windows can remain closed.

These ventilation specifications have historically been accepted by planning authorities to demonstrate compliance with planning policy through the use of conditions, however, since the implementation of ADO, ventilation requirements for buildings have been scrutinised in more detail and verification of performance of acoustic/ventilation systems is now being requested to discharge planning conditions on decision documents.

Increasingly, local planning authorities are considering the practicalities of the use of new dwellings, given the obvious acoustic constraints of some developments, and particularly in relation to the need to open windows, which brings considerations formerly thought to be the province of Building Regulations into the planning agenda as a material consideration.

It is the verification of performance of (as installed) glazing/ventilation systems that is of concern to developers and regulators alike, as while standards for noise reduction are often provided, ventilation efficiency details are difficult to obtain.

## Building Regulations

The Building Regulations and the Approved Documents are issued as mandatory guidance for the construction of buildings and clearly have a significant part to play in addressing compliance with noise standards. Approved Documents, E (Internal Noise), F (Ventilation) and O (Overheating) together provide the basis for a holistic approach to ensuring that occupants' exposure to noise is minimised and internal comfort is assured.

Approved Document E is essentially relying on verifiable performance of building materials and types of construction to achieve the desired performance outcomes. It also relies on appropriate installation according to Robust Details or other approved methods, to provide comfort that internal noise levels can be compliant with appropriate standards. 'As installed' insulation testing in accordance with Approved Document E can provide robust evidence of compliance and helps identify non-compliant elements of the construction, particularly with acknowledged standards like ISO 140 Acoustics —Measurement of sound insulation in buildings and of building elements, and ISO16283 Acoustics —Field measurement of sound insulation in buildings and of building elements to draw on.

The data obtained is based on known sources and measured levels are sufficiently within the measurement range of instrumentation to ensure accurate performance of building elements is obtained and Rw values can be verified.

## Environmental noise and building façades

This approach is broadly the same as that used in determining appropriate façade mitigation where external environmental noise adversely impacts buildings. Specifications for the external building fabric (particularly windows) use the same basic metrics for sound reduction (Rw) as those specified for internal performance. This is no great surprise, and at least provides a numerical basis for determining compliance assuming performance testing of the materials is robust. The only significant difference between internal testing for building regulations and compliance with environmental façade noise is that the post completion test relies almost entirely on the performance of construction elements such as windows not being compromised by poor installation, and the manufacturer data on the building elements is accepted without post installation testing.

Indeed, post installation testing is not normally carried out for the fabric of the building related to environmental noise ingress.

We therefore rely on Building Regulation inspections to ensure that appropriate internal sound levels are achieved, because historically post construction verification of acoustic performance is rarely required through the planning process, moreover, it is likely to be subject to significant uncertainty as external levels are rarely loud enough to generate clearly measurable sound inside rooms with closed windows, and may not be constant enough to give repeatable results, particularly if frequency spectra performance is required.

Similarly, while ventilation provision can be assessed through the simple calculation of required openings vs floor area, or the use of modelling to confirm ventilation requirements, or even dynamic thermal modelling to confirm the requirements for enhanced P50

ventilation to deal with overheating, verification of ventilation has historically rarely been required*.

The advent of ADO has changed the way in which may local planning authorities consider noise impact. The extreme heat experienced in 2019,2021,2022 and 2023 provided evidence of the need to ensure appropriate thermal control of buildings for excess heat, and this appears to have focused on the need to demonstrate that new homes have robust ventilation systems that can cope with excess heat.

And this in turn has promoted a desire for post installation verification that development façade treatment is effective, particularly where a need for acoustic protection exists.

The simple question therefore is; how can these acoustic aspects be balanced with the need for appropriate ventilation, and, more prominently, how can this be demonstrated at reasonable cost?

## AVO Guidance

The 2020 Acoustics Ventilation and Overheating Guidance (AVOG) Version 1.1provided some useful additional guidance that was widely adopted by local planning authorities along with some numerical data on acceptable internal sound levels where overheating might be a factor.

| Location | External free-field noise levels (dB) | Ventilation: Design | Ventilation: Element perfomances | Ventilation: Expected outside -to-inside sound insulation (dB) | Ventilation: Expected internal ambient noise levels (dB) | Overheating condition: Orientation | Room Type | Design | Element performances | Expected outside-to-inside sound insulation (dB) | Expected internal ambient noise levels (dB) | Occurrence | Level 2 assessment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | $L_{Aeq,16h}$ 53<br>$L_{Aeq,8h}$ 45<br>Vent D/C<br>$L_{AFmax}$ 63<br>O'Vent D/C<br>$L_{AFmax}$ 72 | ADF Sys. 1 | Glazing: 31(-6) dB $R_w$ ($C_{tr}$) e.g. 4/16/4 mm double glazing<br>Trickle vent: 34 (-1)dB $D_{n,e,w}$ ($C_{tr}$) | $L_{Aeq,T}$ 23<br>$L_{AFmax}$ 25 | $L_{Aeq,16h}$ 30<br>$L_{Aeq,8h}$ 22<br>D/C<br>$L_{AFmax}$ 38 | All | B&L | Standard opening windows | See Table B-5 | $L_{Aeq,T}$ 13<br>$L_{AFmax}$ 13 | $L_{Aeq,16h}$ 40<br>$L_{Aeq,8h}$ 32<br>D/C<br>$L_{AFmax}$ 59 | N/A | Not required |
| B | $L_{Aeq,16h}$ 59<br>$L_{Aeq,8h}$ 52<br>Vent D/C<br>$L_{AFmax}$ 69<br>O'Vent D/C<br>$L_{AFmax}$ 77 | ADF Sys. 3 | Glazing: 31(-6) dB $R_w$ ($C_{tr}$) e.g. 4/16/4 mm double glazing<br>Trickle vent: 34 (-1)dB $D_{n,e,w}$ ($C_{tr}$) | | | NE | B&L | Standard opening windows | See Table B-5 | $L_{Aeq,T}$ 13<br>$L_{AFmax}$ 13 | $L_{Aeq,16h}$ 46<br>$L_{Aeq,8h}$ 39<br>D/C<br>$L_{AFmax}$ 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. |
| | | | | | | SW | 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<br>$L_{AFmax}$ 22 | $L_{Aeq,16h}$ 40<br>$L_{Aeq,8h}$ 33<br>D/C<br>$L_{AFmax}$ 55 | Often | Increasing likelihood of adverse impact. Below a significant adverse effect. |

Above:
Table B-14

*except for commissioning testing of mechanical ventilation systems

Below:
Figures 2 and 3 of the 2020 Acoustics Ventilation and Overheating Guidance (AVOG) Version 1.1

**Figure B-2** 'AVO Diagram' indicating noise levels associated with adverse effects during the daytime used in this worked example

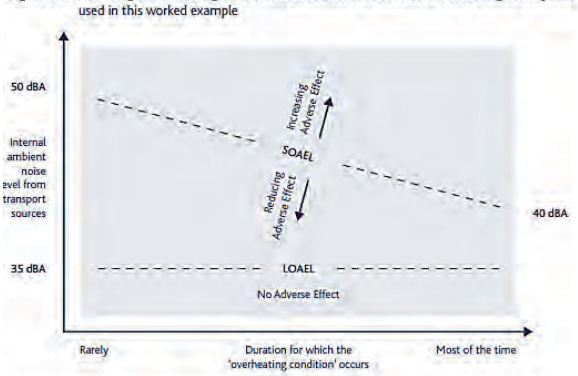
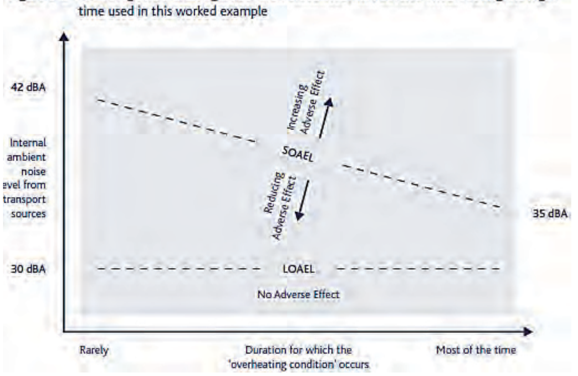



**Figure B-3** 'AVO Diagram' indicating noise levels associated with adverse effects during the night-time used in this worked example




Figures B2 and B3 from the guidance provide a sliding scale of 'acceptable' internal sound levels based on the frequency of overheating events.

This in turn impacts on the need for appropriate ventilation to manage both 'normal' ventilation requirements and ventilation requirements for extreme heat.

The AVOG provides a robust method for assessing the suitability of façade treatments and ensuring that openable windows might be used as part of the solution where internal noise levels would otherwise be unacceptable.

The example output table B-14 (reproduced above), provides useful data on the interface between ADF and ADO, measured external freefield noise levels and expected internal levels for the specified treatment system.

The table helpfully summarises options for treatment and provides outcomes for these options. The expected outside to inside sound insulation assessment is the interesting feature, as this reflects the performance of the façade (read window) while open. It is reasonable to assume that where a high level of reduction is claimed (over the usual 10-15dB normally assumed), that some form of verification may be necessary.

It is the assessment of this performance that is of concern.

## Confirmation of performance

There is no current adopted standard for assessment of the in situ performance of open windows, and the assessment of them is difficult and prone to significant uncertainty. The assessment in situ performance of closed windows and performance of the fabric of the building is likely subject to increased uncertainty.

Building façade performance is frequency dependent, with elements responding differently to noise sources according to the materials used. The potential uncertainty is compounded where source noise changes in level, frequency spectra and angle of incidence with the façade. Variable source data is clearly likely to generate a spread of results reflecting the uncertainty.

Measured internal levels can be very low, and the noise floor of instrumentation can start to influence measured levels. Equally, unoccupied (newbuild) properties may be highly reverberant while occupied properties are likely to be less so. An occupied property (even at night) might have sources operating that would influence internal measurements, for example mains hum, devices on standby, fridge/freezer motors and noise generated by occupants all contributing.

Notwithstanding the above, there are standards that might be used for testing. ISO 16283-3:2016 Acoustics —Field Measurement of Sound Insulation in Buildings and of Building Elements is available, but potentially complex to carry out and expensive for general use.

The ANC issued a document Measurement of Sound in Buildings (2020), that addressed some of these issues and references the above standard. It provides a 'simplified' method (chapter three) that gives some measure of repeatability and reproducibility, but again this may be complex and expensive for large scale use.

Left: Measurement positions 1.5m from glazing, 1.5m above the ground either side of the window. Meters located central to the window

Simply measuring sound levels immediately outside and inside a window may be the simplest option, but clearly the uncertainty noted above could be significant.

The example (see inset photographs and results below) may appear to be 'about right' and the results generated support the conclusion that the internal levels (with windows open) are acceptable for daytime noise, but that the glazing doesn't meet a good acoustic standard.

The window has two opening (shown in photograph) and the road is beyond the trees running parallel to the garden (closest point 20m.)

The measurements taken are simple and do not account for frequency, but provide an indication of the real world performance of this window ~13dB reduction while open and ~22 dB reduction while closed (not unexpected for a 40 year old ill-fitting UPVC window).

The uncertainties associated with the example are essentially those to do with reproducibility, variability in source noise (the road isn't that busy) and potential for undue influence from internal noises in an occupied home, (fridge, freezer, TV on in another room, daughter singing in the kitchen etc). It is likely that the internal levels were higher than expected (particularly those with windows closed) so the result might be conservative.

What is interesting is that comparing the $L_{Aeq}$ is likely to reflect all the uncertainties arising from short duration events, but comparing the $L_{A90}$ avoids this and, at least in the example, seems to provide a similar result.

## Conclusion

Verifying the performance of façades that require acoustic treatment is complex. There is no approved method that underpins the planning process, and while building control has standards derived from ADE, the methods for testing use known generated noise inside rooms that may be inappropriate for external façades, as these artificial sources may not reflect the actual environmental noise exposure.

There are standards that advise on methodologies; ISO 16283-3:2016 and the ANC guidance noted above provide options for assessment with varying degrees of complexity, but again are reliant on significant work to obtain (what could be) a result subject to significant uncertainty. The ANC's guidance recognises this and states:

'Measuring sound within buildings can involve many more complications than are present for external measurements. The simple method proposed may not be appropriate for every situation, but aims to assist in the development of a suitable, bespoke approach.'

The implication is that, whatever the method, the result may be uncertain. As ever, longer duration or repeated assessments under different conditions would provide greater comfort, but also greater expense.

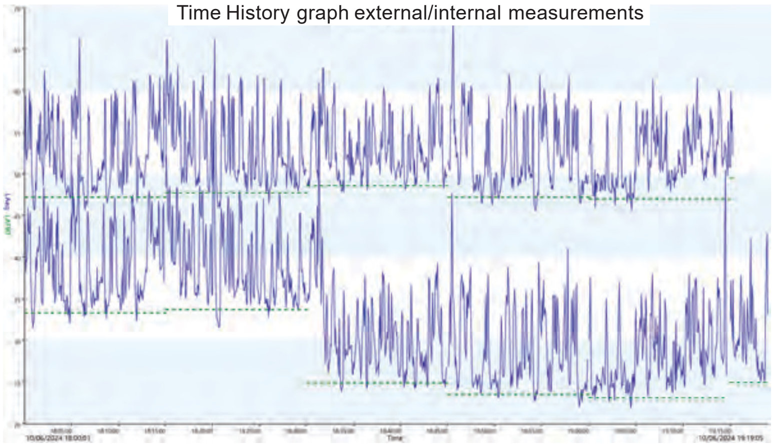
What is needed is a simple endorsed method, ideally aligned to data already available, e.g. octave band acoustic data normally provided for building materials, glazing specifications etc. that might simply be used to verify performance. Ideally, the method should avoid the uncertainty inherent in internal sound level measurement for all but the most complex cases.

The example provided above is clearly very simple, the analysis rudimentary, but it does tell me that the open window sound reduction performance in the real world for that room on that day with road traffic, birdsong and occasional distant farming sounds, was ~ 13dB and ~ 22-23 dB with windows closed. This provides me with sufficient information to draw reasonable conclusions, that measured daytime levels are below 35 dB (compliant) and closed window performance is poor. (I need to replace the window).

However, for a new housing estate seeking to demonstrate compliance with the complex interacting standards of ventilation, overheating and acoustics, something more robust may be needed, but also something simpler to carry out so that the noise exposure of occupants can be as robustly verified as those for ventilation and overheating.

NB: I am advised the standards are currently under review.

Time History graph external/internal measurements



| Duration | | Window open | | Window closed | | |
|---|---|---|---|---|---|---|
| Measurement | | 478 | 479 | 480 | 481 | 482 |
| $L_{Aeq}$ (dB) External | 00:15:00 | 55.3 | 55.5 | 54.5 | 55.1 | 53.5 |
| $L_{Aeq}$ (dB) Internal | 00:15:00 | 41.8 | 42.6 | 39.4 | 32.2 | 32.2 |
| | Difference | 13.5 | 12.9 | 15.1 | 22.9 | 21.3 |
| $L_{A90}$ External (dB) | 00:15:00 | 47.2 | 47.7 | 48.6 | 47.2 | 47 |
| $L_{A90}$ Internal (dB) | 00:15:00 | 33.3 | 33.7 | 24.9 | 23.5 | 23.1 |
| | Difference | 13.9 | 14 | 23.7 | 23.7 | 23.9 |