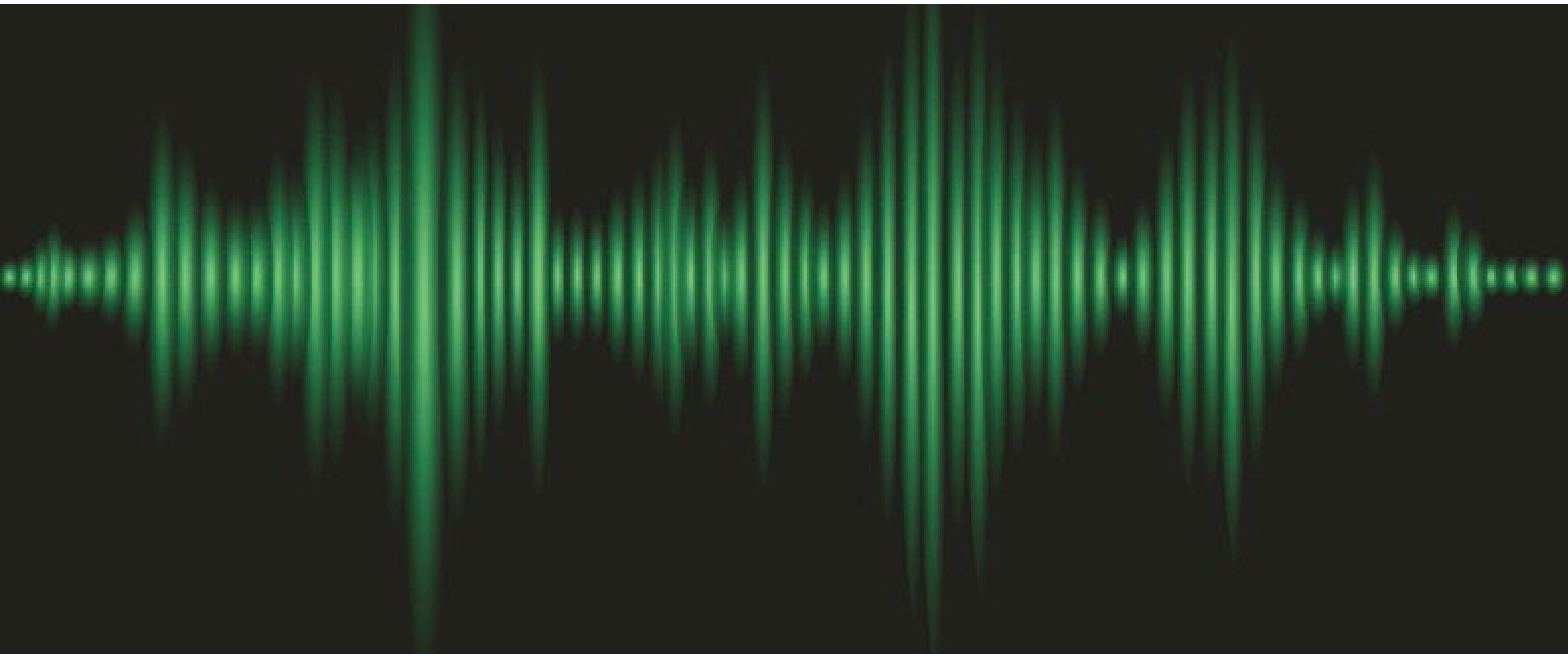
This document provides guidance for practitioners when implementing the requirements of Approved Document O. It is designed to assist the industry in the understanding of what is published in the regulation and provides interpretation and clarification on the content of the published regulation.

This document is published in draft form for consultation and the contents may be developed further in future updates. The advice contained within the latest published version should always be used when seeking to demonstrate compliance with the requirements of Approved Document O.

Guide to Demonstrating Compliance with the Noise Requirements of Approved Document O

July 2022

v1.0



ANC ACOUSTICS & NOISE CONSULTANTS

Institute of Acoustics

This document is published in draft form for consultation

Document Revision No	Reason for Revision	Lead Author	Reviewer	Approver	Date
V1.0	For consultation	See Section 1.3			July 2022

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1. Introduction

1.1. Foreword

1.1.1. Approved Document O 'Overheating' (AD-O, Ref 1) was released in December 2021 and came into effect in England on 15th June 2022. It introduces requirements for various types of residential premises to limit unwanted solar gains in summer and provide an adequate means to remove heat from the indoor environment (Requirement O1 (1)). Requirement O1(2)(a) of the regulation requires that account must be taken of the safety of an occupant, and their reasonable enjoyment of the residence. There is also a requirement (O2(b)) that mechanical cooling may only be used where sufficient heat cannot be removed from the indoor environment without it.

1.1.2. The statutory guidance to support Requirement O1(2)(a), Approved Document O (AD-O) contains requirements relating to noise at night, pollution, security, protection from falling and protection from entrapment.

1.1.3. Paragraph 2.10 of AD-O lists the means for removing excess heat as:

- *Opening windows*
- *Ventilation louvres in external walls*
- *A mechanical ventilation system*
- *A mechanical cooling system*

1.1.4. Under the heading of *Intention*, Approved Document O states that:

> *In the Secretary of State's view, Requirement O(2)(a) is met in a new residential building if the building's overheating mitigation strategy for use by occupants takes account of all of the following:*
>
> *a. Noise at night – paragraphs 3.2 to 3.4*
>
> *b. Pollution – paragraph 3.5*
>
> *c. Security – paragraphs 3.6 and 3.7*
>
> *d. Protection from falling – paragraphs 3.8 to 3.10*
>
> *e. Protection from entrapment – paragraph 3.11*
>
> ***NOTE:*** *Guidance on reducing the passage of external noise into buildings can be found in the National Model Design Code: Part 2 – Guidance Notes (MHCLG, 2021) and the Association of Noise Consultants' Acoustics, Ventilation and Overheating: Residential Design Guide (2020).*

1.2. How Noise at Night Should be Addressed and Considered

1.2.1. Paragraph 3.2 of AD-O states:

> ***3.2*** *In locations where external noise may be an issue (for example, where the local planning authority considered external noise to be an issue at the planning stage), the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (11pm to 7am).*

1.2.2. The example of when noise should be considered (where the local planning authority considered external noise to be an issue…) is useful, but does not define all the situations in which it is necessary to consider noise to comply with the requirements in AD-O. Many residential development sites that do not have planning conditions for noise would fail to comply with the noise requirements in AD-O.

1.2.3. Paragraph 3.3 of AD-O states:

> ***3.3*** *Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.*
>
> *a. 40dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am).*
>
> *b. 55dB L_{AFmax}, more than 10 times a night (between 11pm and 7am).*

1.2.4. Paragraph 3.3 of AD-O objectively defines when relying on opening windows to remove excess heat does not comply with the requirement to take account of noise at night[1].

1.2.5. Paragraph 3.4 of AD-O states:

> ***3.4*** *Where in-situ noise measurements are used as evidence that these limits are not exceeded, measurements should be taken in accordance with the Association of Noise Consultants' Measurement of Sound Levels in Buildings with the overheating mitigation strategy in use.*

1.2.6. Paragraph 3.4 of AD-O, therefore, states that if opening windows is the overheating mitigation strategy that has been adopted, one way of demonstrating compliance with the values in paragraph 3.3 of AD-O would be by making measurements inside a relevant room with windows open sufficiently to remove excess heat[2].

1.2.7. Where an open window[3] for the removal of excess heat will result in the above noise levels being exceeded, the overheating mitigation strategy must adopt one of the alternative means listed in paragraph 2.10 of AD-O. This constraint applies regardless of which method is used to demonstrate compliance with Requirement O1 (1), i.e., the simplified method or dynamic thermal modelling method as described in AD-O.

1.3. Acknowledgements

1.3.1. The guide has been prepared with contributions by the principal authors of the Acoustics, Ventilation and Overheating Guide, namely:

- James Healey, AESG (Chair)
- Anthony Chilton, Max Fordham
- Andrew Long, Sandy Brown
- David Trew, Bickerdike Allen Partners
- Jack Harvie-Clark, Apex Acoustics
- Mathew Hyden, RPS
- Nick Conlan, Apex Acoustics
- Stephen Turner, Stephen Turner Acoustics

1.3.2. Additional support was provided by the following people:

- Robert Adnitt, Adnitt Acoustics
- Robert Osborne, ANC

[1] It is important to note that this paragraph does not define 'noise limits' to be achieved in bedrooms in every situation, but only for the purposes of compliance with AD-O.
[2] This guide presents an alternative approach to demonstrate compliance.
[3] A window that is open sufficiently to remove excess heat. Please refer to Section 3 and 4 for more information.

2. Aims and Interpretations

2.1. Aim of this Guide

2.1.1. This guide sets out a method to demonstrate compliance to the Building Control Body of the noise constraints in Approved Document O. This guide provides clarity for practitioners and regulators so that assessments can be carried out consistently, and the outcome is repeatable and reliable.

2.1.2. Whilst the requirements of Approved Document O are succinct, there is some ambiguity regarding important details. Some of these are addressed below.

2.2. Interpretation of Section 3 (Noise) in AD-O

2.2.1. Which Type of Room in a Dwelling Does the Regulation Cover?

2.2.1.1. Paragraphs 3.2 and 3.3 of AD-O refer to noise within bedrooms at night. Whilst any habitable room could be used as a bedroom, it is proposed that the scope is confined to those rooms specifically designated as bedrooms.

2.2.2. Which Types of Noise are to be Considered?

2.2.2.1. The Approved Document simply uses the term 'external noise'. No further definition is provided in Appendix A of the document. It is considered that the intention is to manage the impact from sound generated from all non-natural sources. Therefore, meteorological sounds such as wind and rain, sound from animals in non-domestic settings (e.g. birds), and sound from water (flowing in rivers, or the sea) are outside the scope. A taxonomy of sound sources can be found in PD ISO/TS 12913-2 [Ref. 5].

2.2.2.2. Consequently, sources such as road, rail and air traffic, sources of an industrial or commercial nature, and sounds arising from entertainment venues are all within scope[4].

2.2.3. What are the Implications at the Planning Stage?

2.2.3.1. The assessment of noise in relation to this regulation is not limited only to sites where the Local Planning Authority consider noise to be an issue. Many sites where the Local Planning Authority did not consider noise to be an issue will nonetheless not comply with the noise level set out in this regulation[5].

2.2.4. Reference Time Period for Internal Noise Levels

2.2.4.1. Approved Document O indicates a threshold of "40dB $L_{Aeq,T}$, averaged over 8 hours", i.e. one full night-time period. This should be based on the typical prevailing external conditions. External noise ingress should be based on the typical annual average external noise with the provisions as required to remove excess heat[6].

2.3. Do the Levels in Section 3.3 Only Apply to Noise via an Open Window?

2.3.1. Paragraph 3.3 of AD-O indicates noise limits when removing excess heat via an open window. These noise levels should also apply to external noise ingress into bedrooms at night associated with any other means of removing excess heat, such as ventilation louvres or ducts.

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[4] For effective noise management, it may be appropriate to use a lower threshold than those presented in paragraph 3.3 of AD-O for sources of an industrial or commercial nature, and sounds arising from entertainment venues, when determining whether opening windows can be used as the overheating mitigation strategy.

[5] Given the means of removing excess heat has the potential to affect the building appearance and/or massing, compliance with this regulation should be considered prior to obtaining planning permission. However, given this is a Building Regulation requirement, it is not necessary to include details of compliance upon submission of the planning application, unless requested by the Local Planning Authority.

[6] Internal noise levels with and without the provisions for removing excess heat should not be averaged

3. Suitably Qualified Person

3.1. AD-O provides information on how to use the approved document and of particular relevance is the statement:

> *Anyone using the approved documents should have sufficient knowledge and skills to understand the guidance and correctly apply it to the building work. This is important because simply following the guidance does not guarantee that your building work will comply with the legal requirements of the Building Regulations.*

3.2. The assessment of a building for compliance with the noise requirements in AD-O requires a suitable level of technical ability and should be undertaken by a Suitably Qualified Person (SQP).

3.3. An individual with all of the following credentials may be considered to be a SQP for this type of assessment:

- Has a minimum of three years' experience (within the last five years) of providing acoustic design advice for buildings. Such experience must clearly demonstrate a practical understanding of factors affecting acoustics in relation to building construction and the built environment in general, including acting in an advisory capacity to provide recommendations and design advice in relation to internal ambient noise levels in residential buildings;

  and

- Holds a recognised acoustic qualification and membership of an appropriate professional body. The primary professional body for acoustics in the UK is the Institute of Acoustics.

3.4. Although the assessment should be led and managed by a SQP, some elements of the assessment (e.g. calculations and measurements) may be carried out by an acoustician who does not meet the requirements above, as long as they carry out their work under the direct guidance and supervision of a SQP.

3.5. Where this is the case, the SQP must, as a minimum, have reviewed and agreed the calculation and / or measurement methodology, and any results. The SQP should confirm in writing that the relevant calculations / measurements:

- Represent good industry practice as set out in this guide.
- Be appropriate given the building being assessed and scope of works proposed.
- Avoid invalid, biased and exaggerated claims.

3.6. Additionally, written confirmation should be provided from the SQP that they comply with the definition of a SQP defined in this guide.

4. Noise Constraints in the Use of the Simplified Method

4.1. External Noise Thresholds

4.1.1. Tables 1.3 and 1.4 of AD-O define minimum free areas for ‘high’ and ‘medium’ risk locations as 13% and 4% of the floor area of the room, respectively. Appendix A of AD-O defines the free area as:

> ***Free area*** *The geometric open area of a ventilation opening. This area assumes a clear sharp-edged orifice that would have a coefficient of discharge (Cd) of 0.62.*

4.1.2. Although the term “free area” is used in AD-O, the definition above is the definition of “Equivalent area”, according to reference [Ref. 6].

4.1.3. Paragraph 1.12 of AD-O states:

> *“The equivalent area of the opening should meet or exceed the free area of the opening…”*

4.1.4. The government FAQs on AD-O[7] (#8) help to clarify that the “minimum free areas” should be met or exceeded by the “equivalent area” of the openings. The term “free area” is used in AD-O to mean “equivalent area”, as indeed it is defined as such.

4.1.5. Paragraph 1.12 of AD-O refers to Appendix D to calculate the equivalent area, where the following explanation is given:

> ***D1*** *The free areas in Section 1 of this approved document are geometric open areas that assume a clear sharp-edged orifice with a 0.62 coefficient of discharge (Cd). Different opening types will reduce the amount of air flow by both affecting the way air flows and reducing the physical area. Accounting for these factors gives the equivalent area.*

4.1.6. The sound insulation performance of any window opening is a function of the hole created in the façade due to the opening of the window. For ease of reference and to differentiate the acoustic factors from the ventilation factors stated in AD-O, this hole can be termed the “acoustic open area”.

4.1.7. Based on typical assumptions (see note below and Appendix A), the resulting outside-to-inside level difference for window openings necessary to satisfy the simplified method of AD-O are expected to be approximately 4 dB for ‘high’ risk locations and 9 dB for ‘medium’ risk locations.

4.1.8. This is a rough calculation of the outside-to-inside level difference for these opening proportions and calculations should be based on actual sound insulation performance data where available. The outside-to-inside level difference may be different for individual noise events (L_{AFmax}) where orientation and free-field propagation are more significant. However, for the purposes of determining the suitability for using the simplified method, it is considered reasonable to use the same values.

4.1.9. With reference to paragraph 3.3 of AD-O, this implies the following limiting external free-field levels above which external noise precludes the use of the simplified method, and dynamic thermal modelling should be used to demonstrate compliance.

Table 1 External Noise Levels Above Which the Simplified Method Cannot Be Used

Parameter	High Risk Location	Moderate Risk Location
$L_{Aeq,8h}$, averaged over 8 hours (between 11pm and 7am)	44 dB	49 dB
L_{AFmax}, more than 10 times a night (between 11pm and 7am)	59 dB	64 dB

Note: Several assumptions have been used to determine the outside-to-inside level difference. These are: 2.4m bedroom height, 0.5s bedroom RT, simple hole in the facade of area sufficient to provide the required equivalent area, no sound transmission other than via the opening. Calculation according to Equation G.1 of BS 8233:2014 [Ref. 7].

[7] https://www.gov.uk/government/publications/overheating-approved-document-o/approved-document-o-overheating-frequently-asked-questions

4.1.10. It may be possible to increase these values and still satisfy the requirements of the simplified method using acoustically specified balconies. For more detail refer to the AVO Guide and Annex D of BS EN ISO 12354-3: 2017 [Ref. 8].

4.2. When is an Assessment Required?

4.2.1. Based on the external noise levels presented in Table 1, it is likely that external noise will be an issue for many sites exposed to only modest levels of noise. A suitably qualified person will need to be used to accurately quantify external night-time noise levels.

4.2.2. There are widely used simple methods to determine environmental noise exposure on a site, such as the noise maps prepared as part of the Environmental Noise Directive, and these can be useful for initially determining possible locations where an open window cannot be used. However, only site-specific detailed predictions or site environmental noise surveys are regarded sufficiently robust to accurately determine compliance with the requirements of the regulation. See Appendix B for further explanation.

4.3. Assessment of Noise

4.3.1. Compliance with Building Regulations is usually determined based on current circumstances. However, with global warming, the risk of overheating will increase in future years. Consequently, it is common for a robust approach to determine an overheating strategy that accommodates reasonably foreseeable future climatic conditions. Therefore, it is also reasonable to develop the noise control solution to accommodate reasonably foreseeable future changes in noise conditions.

4.3.2. Site Noise Surveys

4.3.2.1. A site noise survey is regarded as the most accurate way of establishing current prevailing external noise levels.

4.3.2.2. The Association of Noise Consultants' 'Environmental Noise Measurement Guide' [Ref. 9] provides suitable guidance for equipment specification, scoping, survey methodology, preparation, site work, data handling and storage, and analysis.

4.3.2.3. For example, a sound level meter would normally be expected to comply with precision Class 1 according to IEC 61672-1 [Ref. 10] or BS EN 61672-1 [Ref. 11], demonstrate suitable calibration against a reference standard within the last two years, and be subject to pre- and post-measurement field calibration checks. The uncertainty of unverified instruments cannot be determined with any accuracy.

4.3.2.4. The survey duration should be sufficient to characterise the long-term noise environment during which removal of excess heat is required. In most circumstances this is likely to be represented by the prevailing long-term noise environment which is relatively unchanged throughout the year.

4.3.2.5. The minimum survey duration should include continuous measurements for at least one complete 8-hour night-time period.

4.3.2.6. Where the noise climate is likely to vary significantly from night to night, e.g. where there are low traffic flows, a longer survey duration may be more appropriate to suitably reduce uncertainty.

4.3.2.7. When measuring data for comparison against the L_{AFmax} criterion, an appropriate sampling period is required. Studies [Ref. 12 and Ref. 13] indicate that a measurement sampling time between 1-minute and 3-minutes relates most closely to awakening events compared with longer sampling periods. It is recommended that a sample rate of 2-minutes is used. A longer sampling period can result in a lower assessment of the 10^{th} highest maximum level, and therefore should not be used. A shorter sampling period is acceptable with suitable post-processing of the data.

4.3.3. Predictions

4.3.3.1. External environmental noise levels can be predicted using appropriate calculation algorithms. In England transportation sources are typically predicted using Calculation of Road Traffic Noise (CRTN) [Ref. 14], Calculation of Railway Noise (CRN) [Ref. 15], ANCON & AEDT for Aircraft Noise. The propagation of industrial/commercial noise and of noise maxima are typically predicted using ISO 9613-2 [Ref. 16].

4.3.3.2. Predictions will require additional knowledge of transportation movements for each sound source and will often involve topographical data covering the source location, the intervening ground, and the receptor location, with due account taken of any screening effects.

4.3.3.3. Noise models based on the above calculation algorithms and using site-specific noise survey data as a means of calibration should be used to quantify exposure most accurately.

5. Noise Constraints in the Use of Dynamic Thermal Modelling

5.1. General

5.1.1. Where the simplified method cannot be used, or where the developer decides they want to use an alternative approach to the simplified method, dynamic thermal modelling is required. This follows the procedures of CIBSE TM59 with modifications indicated in AD-O and the government FAQs[7].

5.1.2. The acoustic designer needs to understand the added complexity when using dynamic thermal modelling to evaluate a building. Some variations in approach to removing excess heat may include:

- Varying window open areas
- Opening windows to less than their full extent for the night-time period
- The use of façade openings that have better sound insulation than a traditional open window

5.1.3. Contrary to the wording in paragraph 2.6 of AD-O, the FAQs[7] (#14) indicate that windows may be assessed as partially open at night. To develop a strategy that is useable and satisfies Requirement O1(2)(a), it can be investigated whether the minimum equivalent area needed to remove excess heat and satisfy CIBSE TM59 [Ref. 17] is acoustically feasible. This can be done either by:

1. the acoustic designer advising on the constraint on the angle of opening to achieve the desired acoustic open area for any particular window, and the dynamic thermal modeller then determining if CIBSE TM59 passes or fails with that constraint;

   or

2. the dynamic thermal modeller identifying the minimum window open area (as either an equivalent area or open angle) needed to satisfy CIBSE TM59 and the acoustic designer then determining whether an open window is acoustically feasible by calculating the acoustic open area for the given angle or equivalent area and calculating the normalized element level difference for that opening;

   or

3. the acoustic designer identifying a louvre or ventilator with associated acoustic and aerodynamic performance (e.g. the discharge coefficient), the dynamic thermal modeller identifying the minimum area of the proposed ventilation louvre needed to satisfy CIBSE TM59, and the acoustic designer then determining whether a ventilation louvre is acoustically feasible.

5.1.4. The government FAQs (#12) also confirm that it is allowable to use the adaptive thermal comfort criteria of CIBSE TM59 with bedroom windows closed at night and a mechanical system serving to remove excess heat, provided windows can be opened during the daytime (e.g. bedrooms would still be "predominantly naturally ventilated").

5.1.5. It should be noted that any facade openings referred to below will also need to satisfy the requirements to limit the intake of external air pollutants as set out in paragraph 3.5 of AD-O[8].

5.2. Removing Excess Heat Via an Open Window

5.2.1. The acoustic open areas used to determine the external noise level thresholds should correspond with the window opening angles and hence equivalent areas used in the dynamic thermal modelling. Note that the acoustic open area will always be greater than the corresponding equivalent area for any real open window arrangement.

5.2.2. The outside to inside sound insulation performance via a window opening can then be estimated using the guidance in Annex D of BS EN ISO 12354-3 [Ref. 8].

[8] Paragraph 3.5 of AD-O states: *Buildings located near to significant local pollution sources should be designed to minimise the intake of external air pollutants. Guidance is given in Section 2 of Approved Document F, Volume 1: Dwellings* [Ref. 18].

5.2.3. Where the predictions show an excess of the internal noise levels defined in paragraph 3.3 of AD-O, an alternative means other than an open window should be used to remove excess heat.

5.3. Removing Excess Heat Via a Ventilation Louvre

5.3.1. Where a ventilation louvre is proposed to be used as a means of removing excess heat, the sound insulation of the louvre element combined with all other facade elements likely to contribute to the ingress of external noise should be predicted based on the guidance in BS EN ISO 12354-3 [Ref. 8].

5.3.2. It will be necessary to know the sound reduction or element normalized level difference of the louvre (and the test circumstances underlining the declared performance); the dynamic thermal modeller will need to know the aerodynamic performance of the louvre (e.g. the equivalent area).

5.3.3. Where the mounting of the ventilation louvre in the laboratory differs from the mounting position proposed in-situ, a correction should be applied following the guidance in Annex D of BS EN ISO 12354-3 [Ref. 8].

5.3.4. When using only a ventilation louvre to remove excess heat, the size of the louvre to meet the calculated minimum equivalent area may be determined by the overheating modeller or another designer.

5.3.5. A combination of restricted window openings and a ventilation louvre may be used, provided the contribution from both is accounted for in the prediction of external noise ingress.

5.3.6. Compliance is to be judged for any external noise ingress by comparison against the noise levels in paragraph 3.3 of AD-O.

5.4. Removing Excess Heat Using Mechanical Means

5.4.1. Paragraph 2.1 of AD-O requires that the building should be constructed to meet requirement O1 using passive means as far as reasonably practicable. A passive means in AD-O is defined as any means of cooling a building which is not mechanical cooling (e.g. air conditioning), and includes openable windows and / or mechanical ventilation fans.

5.4.2. Compliance is to be judged for any external noise ingress by comparison against the noise levels in paragraph 3.3 of AD-O.

5.4.3. Noise from any mechanical system should be effectively controlled, so that noise does not become a barrier to occupants for the use of that service. The AVO Guide [Ref. 3] sets out recommended noise levels attributable only to mechanical services, as set out in Table 2, although these are not required under AD-O.

Table 2: Recommended Noise Level for Mechanical Ventilation or Mechanical Cooling Systems

Parameter	Bedrooms
Mechanical ventilation or mechanical cooling system noise	$L_{Aeq,T}$ 30 (±5) dB

5.4.4. See 'Approved Document F, Volume 1: *Dwellings*' [Ref. 18] for further guidance, although noise levels are only specifically identified for whole dwelling and extract ventilation conditions. It may be appropriate to consider noise levels from mechanical systems in other rooms of the dwelling.

5.4.5. Higher noise levels, e.g. by up to 10 dBA may be appropriate in some operating scenarios, where rapid changes to the cooling or ventilation rates quickly improve the thermal comfort of the occupant. Equally, lower noise levels may be appropriate for some types of residential development. When considering variations to the proposed desirable levels, the classification system from ISO/TS 19488 [Ref. 19] may be used as a guide.

5.5. Uncertainty

5.5.1. There is uncertainty inherent in each aspect of the assessment, including:

- measurement equipment – calibrated and certified equipment has known tolerances;
- survey duration –any survey is likely to represent a short-term sample of the typical prevailing noise conditions, which has inherent uncertainty;
- prediction or modelling of sound propagation – this involves assumptions about source location that affect the outcome of the modelling, in addition to the noise propagation model itself;
- façade sound insulation performance - data for open windows and other elements; and
- calculation of façade sound insulation.

5.5.2. The calculation methods of BS EN ISO 12354-3 [Ref. 8] predict performance of buildings from the performance of elements as it can be measured. Section 5 of BS EN ISO 12354-3 [Ref. 8] addresses accuracy and indicates a standard deviation of 1.5 dB for single number ratings such as $D_{ls,2m,nTw}$ + C_{tr}, when calculations are based on performance data (that is around 1 dB lower than laboratory measurement results). The accuracy of the prediction depends on many factors: the accuracy of the input data, the relevance of the calculation compared to the in-situ situation, the type of elements involved, the geometry of the situation, and the type of quantity to be predicted.

5.5.3. It is not possible to specify the accuracy in general for all types of situations and applications. Uncertainty can be effectively managed by following the industry practices as referenced in this guidance. Practitioners should be aware of the potential uncertainty in their assessments.

6. Considerations when Evaluating a Building for Post-construction Compliance

6.1. General

6.1.1. Paragraph 3.4 of AD-O states that one of the options that can be used as evidence that the noise levels in paragraph 3.3 of AD-O are not exceeded is by means of internal measurement in the completed building. Reference is made in AD-O to the use of 'Measurement of Sound Levels in Buildings' [Ref. 4], published by the Association of Noise Consultants.

6.1.2. Given the uncertainty of measuring noise levels internally and the complexity of remedial work to adapt a completed building to remove excess heat by means other than opening a window, it is recommended that determination of compliance with AD-O is completed pre-construction.

6.1.3. If post-completion measurements are used to demonstrate compliance, measurements should be carried out in a suitable sample of rooms. It is recommended that at least 1 in 10 rooms should be measured, and those sampled should include those most exposed to solar gain and those affected by external noise ingress, i.e. those closest to the most significant noise sources, and those requiring the largest ratio of window acoustic open area to room volume to remove excess heat.

6.2. Measurement of Internal Noise Levels

6.2.1. Most situations are likely to be for non-steady intermittent sound and the measurements should be made over a sufficient duration to provide a representative sample of all events to quantify the spread of sound levels experienced throughout the night.

6.2.2. The same measurement duration and sampling time as for external surveys is appropriate. Hence a minimum of one full 8-hour measurement period from 23:00 to 07:00 hours is necessary to assess compliance with the L_{AFmax} criterion.

6.2.3. For assessing the maximum noise levels the sampling time must be appropriate for quantifying the number of individual events that occur during the entire night. For compliance with the noise requirements in paragraph 3.3 of AD-O, a two-minute sampling period is recommended.

6.2.4. The measurement position should be a normally occupied position that is most exposed to the most significant sources of sound.

6.2.5. Unless specified otherwise, measurements should be undertaken with external sources operating under "normal" conditions, e.g. road traffic measurements on a normal weekday, with no extraneous noise (e.g. road works) and when the roads are dry.

6.2.6. Where mechanical services contribute to the overheating strategy, measurements of external noise ingress should be made without the systems operating for a judgement of compliance with the requirements of paragraph 3.3 of AD-O. The measured levels may be standardised to a reference reverberation time of 0.5s as described in the ANC guidance [Ref. 4]. All other procedures should also follow the ANC guidance [Ref. 4].

6.3. Overheating Mitigation Strategy

6.3.1. A key variable for noise levels measured will be the extent that windows or attenuated vents are opened. Ventilators and windows should be open as required based on the overheating mitigation strategy. Where there is a natural ventilation strategy using opening windows, the extent to which windows will need to be opened will depend on the physical arrangement, environmental conditions, and the number of room occupants, as determined in the CIBSE TM59 [Ref. 17] dynamic thermal modelling. All window positions should either represent those used in the dynamic thermal modelling, or it should be demonstrated how the minimum equivalent area is achieved to comply with the simplified method.

6.3.2. The consultant responsible for the dynamic thermal modelling should advise the design requirement for openings. If the extent of opening lights required to meet the design condition cannot be determined because the information is not available at the time of testing, it is suggested that all opening lights are fully opened, and this is noted in the test report.

6.3.3. The extent of any opening during measurement or mechanical system operation should be documented.

7. Reporting

7.1. General

7.1.1. Where evidence is required to demonstrate compliance with Requirement O1(2)(a) and that a building's overheating strategy takes account of noise at night, an acoustic report should be produced.

7.1.2. The report should demonstrate that the noise levels in Section 3.3 of AD-O are not exceeded when the overheating mitigation strategy is in use.

7.1.3. This report could take many forms but should include the following information as a minimum:

- The client
- The project name and location
- Identification of the overheating assessment that this acoustic report is applicable to (e.g. name of CIBSE TM59 [Ref. 17] Assessor and relevant overheating assessment report reference / revision no.).
- A summary of the overheating mitigation strategy being assessed in the acoustic report.
- Identification of the noise levels inside bedrooms at night when the building overheating mitigation strategy is in use.
- Description of the methodology used to obtain internal noise levels within bedrooms at night.

7.1.4. If internal noise levels are obtained by calculation, the methodology used should be described and the following information should also be provided:

- External $L_{Aeq,8h}$ and L_{AFmax} noise levels used to calculate noise levels within bedrooms.
- Description and justification of the methodology used to obtain the $L_{Aeq,8h}$ and L_{AFmax} noise levels incident on the building
- Assumed sound insulation of the building facade components
- Justification for assumed sound insulation of any facade openings and confirmation they align with the relevant assumptions in the CIBSE TM59 [Ref. 17] assessment (e.g. equivalent area and opening times)
- Any assumptions made about the receiving room / location including, where relevant, room / facade dimensions, volume and absorption area.

7.1.5. Any design report should have a clear concluding section setting out any noise mitigation proposed for the removal of excess heat.

7.1.6. If internal noise levels are obtained through measurement, the report should follow the reporting requirements as listed in the ANC guidelines, with the addition of:

- The observed strategy for removal of excess heat in place when undertaking the measurements.

8. Glossary

Noise	Typically defined as unwanted, unpleasant or disturbing sound
Frequency (Hz)	The number of oscillations in acoustic pressure per second. It represents the 'tone' of the sound. Often determined in octave bands
Maximum sound pressure level (L_{Fmax})	The maximum or highest sound pressure level measured with a 'fast' time weighting
Equivalent continuous sound pressure level ($L_{eq,T}$)	The average of the total sound energy over a specified time period (T). L_{eq} represents the equivalent sound level that a fluctuating source would have compared to a steady source with the same total sound energy over a specific time period. Commonly used as a descriptor of human perception of sound over time.
'A' weighting	Frequency-dependent weighting based on the response of the human auditory system which has been found to correlate well with the subjective response to sound. Denoted by the use of the letter 'A'. For example, dBA denotes an 'A' weighted sound level in decibels, or L_{Amax} denotes an 'A' weighted maximum sound pressure level.
Internal Ambient Noise Level (IANL)	The noise level within a room or enclosed space. Usually determined as an equivalent continuous sound pressure level over a specific time period ($L_{Aeq,T}$, dB)
Noise Rating (NR) curve	A single figure term used to reflect the spectral frequency content of noise. Although originally proposed to assess environmental noise, NR curves are now typically used to describe noise from mechanical ventilation systems in buildings.
$L_{night,outside}$	The incident external A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year, in which the night is eight hours between 23:00 and 07:00.
AVO	Acoustics, Ventilation, Overheating (e.g. AVO Guide, AVO Group).
Overheating Strategy Overheating Condition	The situation where measures are in place to mitigate overheating to meet agreed compliance criteria.
Dynamic thermal modelling	A technique that can be used to simulate internal temperatures in dwellings before they are built
Ventilative cooling	Cooling by means of introducing external ambient temperature air at a high ventilation rate. Can be either passive (no fans) or mechanical (with fans).
Purge ventilation	Ventilation to aid removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating or accidental releases such as smoke from burnt food or spillage of water.
Mechanical cooling	Cooling by means of a refrigerant cycle. This would include 'air conditioning' systems and the use of fan coil units (FCUs).
MEV	Mechanical extract ventilation.
"Free area" as used in AD-O	Approved Document O uses the term "Minimum free area" that is required to be achieved by the Equivalent area of the window openings. AD-O provides the accepted definition of Equivalent area for the description of "free area". The term "free area" is therefore avoided in this document to avoid further confusion.
Acoustic open area	The measurable, cross-sectional, geometric area of an opening. For a partially open window, this is considered to be the lesser of either the size of the hole in the window frame that is left by the opening light, or the combined cross-sectional area around the opening light through which air must pass to move from outside to inside. The area around a hinged opening light includes the triangular areas on the sides adjacent to the hinge, and the rectangular area on the side opposite the hinge. This should not be used for comparing the air-flow performance of elements because this will also be dependent on factors such as depth (length of air-path), surface roughness and tortuosity. Refer to reference 6 for further information.
Effective area, A_{eff}	Defined as the product of the free area and discharge coefficient, this is the preferred parameter for comparing the air-flow performance of elements. Refer to reference 6 for further information.
Equivalent area, A_{eq}	The area of a sharp-edged, circular orifice that gives the same flow rate as the actual opening at a given pressure-difference. In other words, the free-area of a notional circular hole made in an infinitely thin, infinite extent baffle that gives the same air-flow performance as the real opening. Used to describe the area of trickle vents in Approved Document F. Not to be confused with Effective area. Refer to reference 6 for further information.
Coefficient of	The ratio of the mass flow rate at the discharge end of the nozzle to that of an ideal nozzle which expands an

Discharge, Cd	identical working fluid from the same initial conditions to the same exit pressures.
ANCON	Aircraft Noise Contour Model, by the Civil Aviation Department
AEDT	Aviation Environmental Design Tool, by the Federal Aviation Administration

Appendix A. Explanation Behind Approach

A.1. Method for Determining External Noise Thresholds

Consider a bedroom of 10 m^2 in a high-risk area, the equivalent area required is 1.3 m^2 (13 % x 10 m^2). From Table D9 in Annex D of AD-O for windows open 90 degrees, this could be achieved with either two opening lights of 0.75m x 1.0m (w x h), or one opening light of 1.0m x 1.5m, if that could be opened to 90 degrees. Note, if these example windows open outwards, they must also comply with the requirement that the handle is not more than 650 mm from the inside face of the wall as specified in paragraph 3.9 of AD-O.

The sound insulation of the acoustic open area can be estimated using the guidance in Annex D of BS EN 12354-3:

$$D_{n,e} = -10\lg\left(\frac{S_{open}}{A_0}\right) \qquad (D.1)$$

where

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

A_0 is the reference equivalent sound absorption area, in square metres for dwellings given as 10 m^2.

The acoustic open area of a window open more than about 30 degrees is the size of the hole that the opening light leaves in the plane of the facade. Thus, to achieve an equivalent area of 4 % of the floor area, it is likely that the acoustic open area will need to be about 5 % of the floor area, and to achieve 13 % of the floor area, an acoustic open area of about 15 % of the floor area will be required. These values are only achieved if the window opening areas are sized optimally for the room dimensions. If the opening windows are over-sized, the sound insulation achieved will be correspondingly lower.

To estimate the internal noise level from the predicted acoustic open area, Equation G.1 of BS 8233:2014 can be used, reduced for a single element as follows:

Equation 1

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

Where:

L_2 is the internal level

$L_{1,ff}$ is the free-field external level (i.e. assumed to be 3 dB lower than a level 1m away from the façade according to BS 8233)

R is the sound reduction index, assumed to be zero for the open area, S (m^2)

T is the reverberation time, 0.5 seconds for the standardised internal level

V is the room volume (m3). Consider as the floor area x room height.

S, open area as a fraction of floor area, e.g. 0.05 x floor area.

The floor areas cancel, and for 5 % of the floor area to be open and a room height of 2.4 m:

Equation 2

$$L_{1,ff} - L_2 = 0 - 10.\log\left(\frac{0.05x0.5}{2.4}\right) - 11 = 9\ dB$$

Similarly, considering the requirement for an Equivalent area of 13 % of the floor area in high-risk areas, it is possible that an acoustic open area of 15 % of the floor area can suffice. Using a value of 0.15 in equation 1 for the fraction of floor area indicates a difference between external free-field and internal reverberant levels of 4 dB.

A.2. Limitations on Using Basic Noise Exposure Tools

Noise maps have been prepared in England as part of the Environmental Noise Directive. These maps are used for strategic noise management purposes and are only currently available for agglomerations (towns/cities) as well as around main transport infrastructure. Noise mapping data may be used to provide an initial indicator of whether night noise might be an issue. However, information is only available for the L_{night} indicator (which can be regarded as the annual average $L_{Aeq,8h}$); data is only provided down to 50 dB and predictions are only made for agglomerations with a population of more than 100,000 people, on major roads with more than 3,000,000 vehicle passages per year, on major railways with more than 30,000 train movements per year and for major airports.

No evidence for night-time L_{AFmax} noise levels currently exists from publicly available noise mapping data. It is possible to estimate the potential L_{AFmax} noise level from a range of vehicles using information within guidance such as The Noise Advisory Council's 'A Guide to Measurement and Prediction of the Equivalent Continuous Sound Level Leq', provided road traffic volumes and types are known. The statistical relationship between continuous equivalent and maximum noise levels at night has been demonstrated by Conlan et al in 'Empirical relationship between L_{night} and L_{Amax}', Proc. IOA 2021. It is also possible to estimate the L_{AFmax} noise level of passing trains from SEL data in CRN, adjusted to L_{AFmax} using standard techniques, and known data on rail movements. Any prediction of L_{AFmax} must be sufficiently extensive to result in reasonable comfort that the predicted level represents the 10th highest noise maxima. Any propagation adjustments to the L_{AFmax} level should be undertaken based on ISO 9613 and assume a point source propagation, i.e. 20xLog(distance), rather than a line source propagation. It is prudent to assume typical worst-case locations for a point source of noise affecting different receptor locations. There is no publicly available discrete data source for non-transportation sources such as industrial / commercial noise or entertainment noise.

Further limitations to using these approaches are as follows:

- The date of the data used may not reflect the date of the scenario being considered
- The height of the data points may not reflect the height of the receptor(s) being considered (strategic noise map data represents noise at 4m height)

For the reasons above, these tools are not regarded as sufficiently robust to act as a demonstration of compliance with a Building Regulations requirement.

Appendix B. References

Ref	Title	Author/Publisher	Year
1	Approved Document O – Overheating (2021)	HM Stationary Office	2021
2	National Model Design Code: Part 2 – Guidance Notes	Ministry of Housing, Communities and Local Government	2021
3	Acoustics, Ventilation and Overheating: Residential Design Guide	Association of Noise Consultants / Institute of Acoustics	2020
4	Measurement of Sound Levels in Buildings	Association of Noise Consultants	2020
5	ISO/TS 12913-2:2018 'Acoustics — Soundscape — Part 2: Data collection and reporting requirements'	International Standards Organisation	2018
6	A review of ventilation opening area terminology, Energy and Buildings 118, 249-258	BM Jones, MJ Cook, SD Fitzgerald, CR Iddon	2016
7	British Standard 8233:2014 'Guidance on sound insulation and noise reduction for buildings'	British Standards Institution	2014
8	BS EN ISO 12354-3:2017 'Building acoustics. Estimation of acoustic performance of buildings from the performance of elements - Airborne sound insulation against outdoor sound'	British Standards Institute	2017
9	Environmental Noise Measurement Guide	Association of Noise Consultants	2021
10	IEC 61672-1:2013 'Electroacoustics - Sound level meters - Part 1: Specifications'	International Electrotechnical Commission	2013
11	BS EN 61672-1:2013 'Electroacoustics. Sound level meters Specifications'	British Standards Institute	2013
12	Night Noise Guidelines for Europe	World Health Organization	2009
13	Assessing Lmax 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	2019
14	Calculation of Road Traffic Noise	Department of Transport Welsh Office	1988
15	Calculation of Railway Noise	Department of Transport	1995
16	ISO 9613-2: 1996 'Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation'	International Standards Organisation	1996
17	CIBSE TM59 Design methodology for the assessment of overheating risk in homes	Chartered Institute of Building Services Engineers	2017
18	Approved Document F – Ventilation, Volume 1: Dwellings (2021)	HM Stationary Office	2021
19	ISO/TS 19488:2021 'Acoustics — Acoustic classification of dwellings'	International Standards Organisation	2021
20	Directive 2002/49/EC Environmental Noise Directive	European Union	2002

This document is published in draft form for consultation

GUIDE TO DEMONSTRATING COMPLIANCE WITH THE NOISE REQUIREMENTS OF APPROVED DOCUMENT O

July 2022

v1.0

This document is published by the Association of Noise Consultants

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