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APPROVED DOCUMENT O
NOISE GUIDE

Disclaimer

This document provides guidance for practitioners when implementing the standards within the Building Regulations (2010) Approved Document O (England) relating to noise. It is designed to assist in understanding the guidance in the regulation and provide interpretation and clarification on the content of the published regulation.

Contents

1. Introduction

1.1 Acknowledgements

1.1.1 The preparation of this guide was overseen by a Working Group consisting of representatives of the Association of Noise Consultants (ANC) and Institute of Acoustics (IOA).

1.1.2 This edition of the guide has been developed after considering feedback from the broader membership of the ANC and IOA. We gratefully acknowledge the support and valuable advice received from members during the consultation phase.

1.1.3 The core members of the Working Group were the principal authors of the Acoustics, Ventilation and Overheating Guide [Ref. 1], namely:

- James Healey, Peninsular Acoustics (Chair)
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1.1.4 Additional support was provided by the following people:

- Robert Adnitt, Adnitt Acoustics
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1.2 Foreword

1.2.1 The Building Regulations (2010) Approved Document O 'Overheating' (England) [AD-O, Ref. 2] 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.

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

1.2.3 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*

1.2.4 Under the heading of Intention, AD-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).

1.3 How Noise at Night Should be Addressed and Considered

1.3.1 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).

1.3.2 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 standards in AD-O. Many residential development sites that do not have planning conditions for noise would fail to comply with the noise standards in AD-O. Therefore, the words 'for example' are important in that consideration of noise is not limited to situations where the local planning authority considered external noise to be an issue.

1.3.3 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).*

1.3.4 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].

1.3.5 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.

1.3.6 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. This guide presents an alternative approach to demonstrate compliance.

1.3.7 Where an open window[2] 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 It is important to note that this paragraph does not define 'noise limits' to be achieved in bedrooms, but only for the purposes of demonstrating compliance with AD-O.

2 A window that is open sufficiently to remove excess heat. Please refer to Section 4 and 5 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 AD-O. This guide aims to provide 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 AD-O are succinct, there is some ambiguity regarding important details. Some of these issues 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 AD-O. 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 (except those associated with commercial premises, e.g. kennels), and sound from water (flowing in watercourses, or the sea) are outside the scope.

2.2.2.2 Consequently, sources such as road, rail and air traffic, sources from industrial or commercial premises, sounds arising from entertainment venues and noise arising from other commercial premises (e.g. kennels and agriculture) are all within scope[3].

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. It cannot be assumed that sites where the Local Planning Authority did not consider noise to be an issue will comply with the noise level set out in this regulation[4].

2.2.4 Reference Time Period for Internal Noise Levels

2.2.4.1 AD-O simply 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 representative prevailing external conditions. See the Association of Noise Consultants' 'Environmental Sound Measurement Guide' [Ref. 5] for further information.

2.2.5 Reference Room Conditions for Internal Noise Levels

2.2.5.1 AD-O simply indicates internal threshold levels but does not state the corresponding room acoustic conditions. When determining compliance, the room conditions should be normalized to a reference reverberation time of 0.5s.

3 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.

4 Given the means of removing excess heat has the potential to affect the building appearance and/or shape or form, 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.

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 louvres or trickle vents.

3. Suitably Qualified Person

3.1 AD-O provides information on how to use the approved document and of 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 standards 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 the following credentials may be considered to be a SQP for this type of assessment:

- 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; and
- 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.

3.4 Although the assessment should be led and managed by a SQP, the assessment 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.
- Do not include 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. AD-O Simplified Method

4.1 External Noise Thresholds for AD-O Simplified Method

4.1.1 Tables 1.3 and 1.4 of AD-O define minimum free areas for 'high' and 'medium' risk locations[5] as 13% and 4% of the floor area of the bedrooms, 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 a study presented in the paper 'A review of ventilation opening area terminology' [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[6] (FAQ #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 Based on research and typical assumptions (see note below Table 1 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 5 dB for 'high' risk locations and 10 dB for 'medium' risk locations.

4.1.7 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)	45 dB	50 dB
L_{AFmax}, more than 10 times a night (between 11pm and 7am)	60 dB	65 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 façade 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].

4.1.8 These values do not account for façade elements in front on the window (e.g. balconies).

5 As defined in Appendix C of AD-O

6 www.gov.uk/guidance/approved-document-o-overheating-frequently-asked-questions

4.2 When is a Noise Assessment Required?

4.2.1 Based on the levels in Table 1, it is likely that external noise will be an issue for many sites. A suitably qualified person will need to be used to quantify accurately 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 implementing the Environmental Noise (England) Regulations 2006 (as amended). These can be useful for scoping and evaluating whether the Simplified Method can be used for specific development sites. However, only site-specific detailed predictions or site environmental noise surveys are regarded as being sufficiently robust to accurately determine compliance with the standards 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. Nevertheless, it is appropriate 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 For this assessment a site noise survey is regarded as the most appropriate way of establishing current prevailing external noise levels.

4.3.2.2 The Association of Noise Consultants' 'Environmental Sound Measurement Guide' [Ref. 5] provides suitable guidance for equipment specification, scoping, survey methodology, preparation, site work, data handling and storage, and analysis.

4.3.2.3 For example, the uncertainty of unverified instruments cannot be determined with any accuracy and a sound level meter would normally be expected to:

- comply with precision Class 1 according to IEC 61672-1 [Ref. 8] or BS EN 61672-1 [Ref. 9]'
- demonstrate suitable calibration against a reference standard within the last two years; and
- be subject to pre- and post-measurement field calibration checks.

4.3.2.4 The survey duration should be sufficient to characterise the long-term noise environment that can be considered representative in terms of noise exposure. In most circumstances this is likely to be characterised 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 environment 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 reduce uncertainty.

4.3.2.7 When measuring data for comparison against the L_{AFmax} criterion, an appropriate sampling period is required. Studies [Ref. 10 and Ref. 11] indicate that a measurement sampling period between 1-minute and 3-minutes relates most closely to awakening events compared with longer sampling periods. It is recommended that a sample period of 2-minutes is used. A longer sampling period can result in a lower assessment of the 10th highest maximum level, and therefore should not be used. A shorter sampling period can be used 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. 12], Calculation of Railway Noise (CRN) [Ref. 13] and ECAC.CEAC Document 29 Volume 2 for Aircraft Noise [Ref. 14]. The propagation of industrial/commercial noise and of noise maxima are typically predicted using ISO 9613-2 [Ref. 15]. Prediction of an L_{AFmax} event should only be done by assuming point source propagation.

4.3.3.2 Predictions will require additional knowledge of transportation movements for each sound source and should usually include 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 Computer 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 [Ref. 16] with modifications indicated in AD-O and the government FAQs[6].

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; and
- The use of façade openings that have better sound insulation than a traditional open window.

5.1.3 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 (i.e. bedrooms would still be "predominantly naturally ventilated").

5.1.4 It should be noted that any façade openings referred to below will also need to satisfy the standards to limit the intake of external air pollutants as set out in paragraph 3.5 of AD-O[7].

5.1.5 Before establishing an approach to remove excess heat, the external noise level at each bedroom window shall be established and defined.

5.2 Removing Excess Heat Via an Open Window

5.2.1 Contrary to the wording in paragraph 2.6 of AD-O, the FAQs[6] (#14) confirms that windows may be assessed as partially open at night.

5.2.2 Where noise and air quality are not a constraint, the primary approach to remove excess heat should be via an open window. From the established external noise exposure at each bedroom window, the outside to inside level difference should be calculated, and then the target Equivalent Area should be predicted using the following equations (depending on whether the required level difference is free-field or façade):

Equation 1[8]

$$EA\ based\ on\ façade\ level\ difference = V \times 10^{\left(\frac{-(D_{2m,nT}+5)}{10}\right)}$$

Where

$D_{2m,nT}$ is the is the façade level difference between the A-weighted level 2m in front of the façade ($L_{1,2m}$), and the standardised internal A-weighted level ($L_{eq,2,nT}$). In the absence of any better alternative method, the same principle can be applied to L_{AFmax}.

V is the room volume (m³)

EA is the Equivalent Area of the open window (m²)

7 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].

8 See Appendix A for limitations on the use of this formula.

Equation 2[8]

$$EA\ based\ on\ freefield\ level\ difference = V \times 10^{\left(\frac{-(D_{nT}+8)}{10}\right)}$$

5.2.3 The total maximum Equivalent Area for each bedroom to meet the required standardised level difference should then be communicated to the dynamic thermal modelling consultant.

5.2.4 Where a bedroom has more than one window, the total noise through all window openings is required to meet the noise standards in AD-O.

5.2.5 See Appendix A for further information on removing excess heat via an open window.

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 façade elements likely to contribute to the ingress of external noise should be predicted based on the guidance in BS EN ISO 12354-3 [Ref. 17].

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. 17].

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 taken into account in the prediction of external noise ingress.

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

5.4.3 Where windows are required to be closed at night and an extract fan is used to remove excess heat, fresh air is typically provided by façade openings. Any associated façade openings needed for ventilation should be designed to uphold the sound insulation necessary to achieve the noise standards of AD-O.

5.4.4 Noise from any mechanical system should be effectively controlled, so that it does not discourage occupants from using that system. The AVO Guide [Ref. 1] sets out recommended noise levels attributable only to mechanical services, as set out in Table 2, although these are not formally required to comply with 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

5.4.5 Approved Document F (England) [Ref. 18] provides 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.

5.4.6 Higher noise levels than those in Table 2, 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 Assessment Steps

5.5.1 To determine if an open window can be used for removing excess heat, it is recommended that the acoustic consultant adopts the following process:

1. Establish the night-time noise exposure at all bedroom windows as advised in this document;
2. Determine the outside to inside sound insulation for each bedroom window required to meet the noise threshold;
3. Determine the Equivalent Area to achieve the required outside to inside sound insulation as determined in 2) above; and
4. Communicate the required total maximum night-time Equivalent Area via an open window for the dynamic thermal modeller to use.

5.5.2 For bedrooms that cannot rely on an open window to remove excess heat at night due to noise constraints, the thermal modeller should identify the solution to remove excess heat. The acoustic consultant can then advise the acoustic requirements for any proposed provisions.

5.5.3 One clear way of communicating the advice is to provide a mark-up showing the required performance at each façade / window.

5.5.4 The dynamic thermal modelling report should contain sufficient reference to any associated noise assessment, the required sound insulation performance and maximum night-time Equivalent Area and the basis for defining these.

5.6 Uncertainty

5.6.1 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.

5.6.2 The calculation methods of BS EN ISO 12354-3 [Ref. 17] predict performance of buildings from the performance of elements as they can be measured. Section 5 of BS EN ISO 12354-3 [Ref. 17] 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 type of element involved, the geometry of the situation, and the type of quantity to be predicted. In the case of the sound insulation via an open window, uncertainty can be minimised by using research undertaken in actual dwellings rather than in the laboratory.

5.6.3 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 at the design stage only.

6.1.3 This is also the approach set out in AD-O regarding the demonstration of compliance with the overheating standards in respect of Sections 1 and 2.

6.1.4 If measurement is used, it is recommended that at least one bedroom on each façade is tested, and those sampled should include those most exposed to solar gain and those most affected by external noise ingress, i.e. those closest to the most significant noise sources, and those requiring the largest ratio of Equivalent Area to room volume.

6.2 Measurement of Internal Noise Levels

6.2.1 If post-completion measurements are required to be used to demonstrate compliance and the façade is exposed to continuous road traffic, the following process is recommended:

- Identify the external noise exposure (ideally using the conditions established to inform the design);
- Measure the simultaneous external and internal noise levels and internal reverberation time using the global road traffic methodology in BS EN ISO 16283-3: 2016 [Ref. 20] and with the façade elements set open to match the amount used as the basis of the overheating assessment;
- Calculate the internal noise level from the external noise exposure and the measured outside to inside level difference normalized to 0.5s reverberation time; and
- Compare against the noise standards in AD-O.

6.2.2 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.

6.2.3 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 standards of paragraph 3.3 of AD-O. The measured levels should also 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. 16] 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 window opening 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 windowpanes are fully opened to 650mm extent[10], 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.

10 Measured from the window handle to the inside face of the external wall, as defined in AD-O.

7. Reporting

7.1 General

7.1.1 Where evidence is required to demonstrate compliance with Requirement O1(2)(a) that a building's overheating strategy takes account of noise at night, the noise constraints and the basis for definition should be communicated. This could take the form of a full report, a short memo or a section within the modelling report used to communicate the overheating strategy.

7.1.2 Any reporting should demonstrate that the noise levels in Section 3.3 of AD-O are not exceeded when the overheating mitigation strategy is in use. Where an open window is utilised in the overheating strategy, this is best done by stating the total Equivalent Area required per bedroom for noise mitigation and the overheating report demonstrating that the used Equivalent Area does not exceed these limits.

7.2 Report Contents

7.2.1 Any reporting should include the following information as a minimum:

- The client;
- The project name and location;
- A summary of the overheating mitigation strategy being assessed;
- 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 façade components;
- Justification for assumed sound insulation of any façade openings and confirmation they align with the relevant assumptions in the CIBSE TM59 [Ref. 16] assessment (e.g. Equivalent Area and opening times);
- Any assumptions made about the receiving room / location including, where relevant, room / façade dimensions, volume and absorption area; and
- Identification of the noise levels inside bedrooms at night when the building overheating mitigation strategy is in use, or an explanation of how the outside to inside sound insulation has been defined.

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

7.2.3 If internal noise levels are obtained through measurement, the report should follow the reporting advice 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.
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.
Mechanical cooling	Cooling by means of a refrigerant cycle. This would include 'air conditioning' systems and the use of fan coil units (FCUs).
"Free area" as used in AD-O	AD-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.
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 Discharge, Cd	The ratio of the mass flow rate at the discharge end of the nozzle to that of an ideal nozzle which expands an identical working fluid from the same initial conditions to the same exit pressures.

Appendix A. Explanation Behind Approach

A.1 Aligning Acoustic & Thermal Models

It is suggested in Annex D of BS EN 12354-3 that the sound insulation of small openings can be estimated using the following equation:

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

Where

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

A_0 *is the reference sound absorption area, in square metres with a value of 10 m^2.*

Research [Ref. 21] has established that the use of Equivalent Area for the term S_{open} in the equation above has an equivalent accuracy in real-world performance as the use of a physical open area. Consequently, by using Equivalent Area, the Suitably Qualified Person can define the total Equivalent Area for each bedroom, and this is terminology that is better understood by dynamic thermal modellers. Using this approach will improve coordination and ensure more sites have noise mitigation reflected in the thermal model.

The same research has indicated that the upper limit of normalized level difference for a window open to an extent as little as 50mm is up to 20dB $D_{n,e,w} + C_{tr}$.

A.2 External Noise Thresholds for Simplified Method

The Simplified Method requires the assessment to assume the following (as stated in Tables 1.3 and 1.4 of AD-O:

Bedroom minimum free area	13% of the floor area of the room(4)	4% of the floor area of the room (4)

As confirmed, 'free area' should be taken to mean Equivalent Area.

Where the only significant external sound ingress route is through an open window, the façade level difference can be calculated according to Equation 3.

Equation 3

$$D_{2m,nT} = L_{1,2m} - L_{eq,2,nT} = 10 \times \log\left(\frac{V}{S_{open}}\right) - 5$$

Where

$D_{2m,nT}$ is the façade level difference between the A-weighted level 2 m in front of the façade ($L_{1,2m}$), and the standardised internal A-weighted level ($L_{eq,2,nT}$). It is assumed that sound ingress through an open façade surface area, S_{open}, dominates the transmission, as other ingress routes are not considered here [dB]

V *is the volume of the receiving room [m^3]*

S_{open} *is the area of the façade element [m^2]*

According to EN 12354-3 and ISO 1996, the relationship between $L_{Aeq,8h}$ and $L_{1,2m}$ for a plain façade where the façade shape factor ΔL_{fs} = 0 is given by Equation 4.

Equation 4

$$L_{1,2m} = L_{Aeq,8h} + 3$$

It is convenient to express the Equivalent Area as a fraction of the floor area. When the ceiling height is 2.4 m, the open area to achieve 40 dB $L_{Aeq,8h}$ inside as a fraction of the floor area is given by Equation 5.

Equation 5

$$EA\ per\ m^2\ floor\ area\ \leq 2.4 \times 10^{\left(\frac{32 - L_{Aeq,8h}}{10}\right)}$$

The free-field equivalent requirement is assumed to be 3 dB less, meaning for an Equivalent Area 4% of the floor area, the free-field outside to inside level difference is 10 dB.

Similarly, considering the requirement for an Equivalent Area of 13 % of the floor area in high-risk areas indicates a difference between external free-field and internal reverberant levels of 5 dB where the average ceiling height is 2.4m.

A.3 Limitations on Using Basic Noise Exposure Tools

Noise maps have been prepared in England as part of the Environmental Noise Directive [Ref. 22]. 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' [Ref. 23], 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}', [Ref. 24]. 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. 20 x log (distance/reference distance[11]), 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)

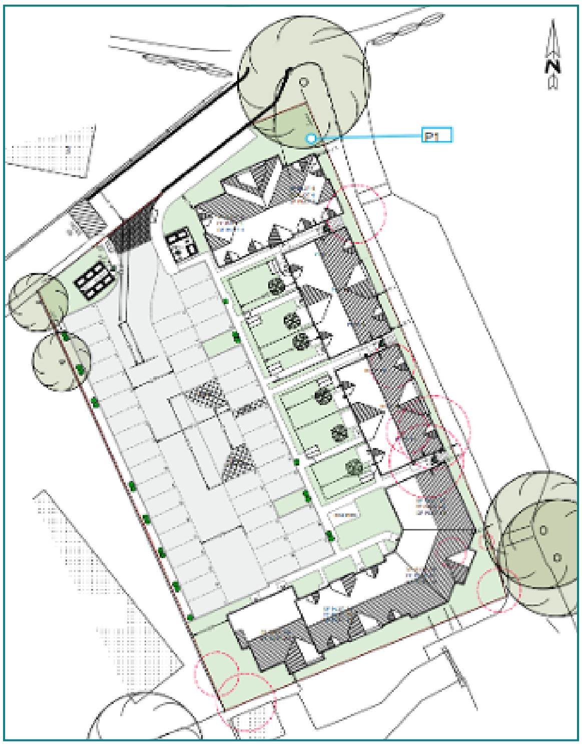
For the reasons above, these tools are not regarded as sufficiently robust to act as a demonstration of compliance with a Building Regulations requirement.

11 In metres

Appendix B. Examples

Example 1: A Site with Flats and Houses, with Varying Noise Exposure

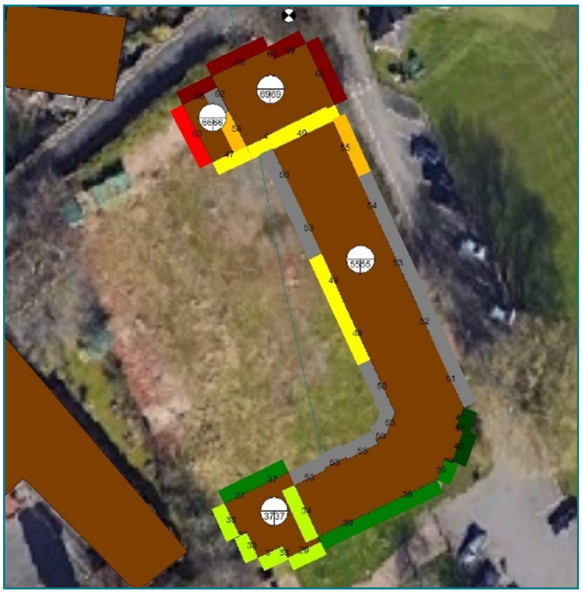
Two blocks of flats and two blocks of semi-detached houses are proposed on a site. A night-time noise survey was undertaken in free-field conditions in accordance with the methods set out in this Guide, at position P1 as shown on the site plan below.



Parameter	Results
$L_{Aeq,8h}$	57 dB
10th Highest $L_{AFmax,2m}$	72 dB

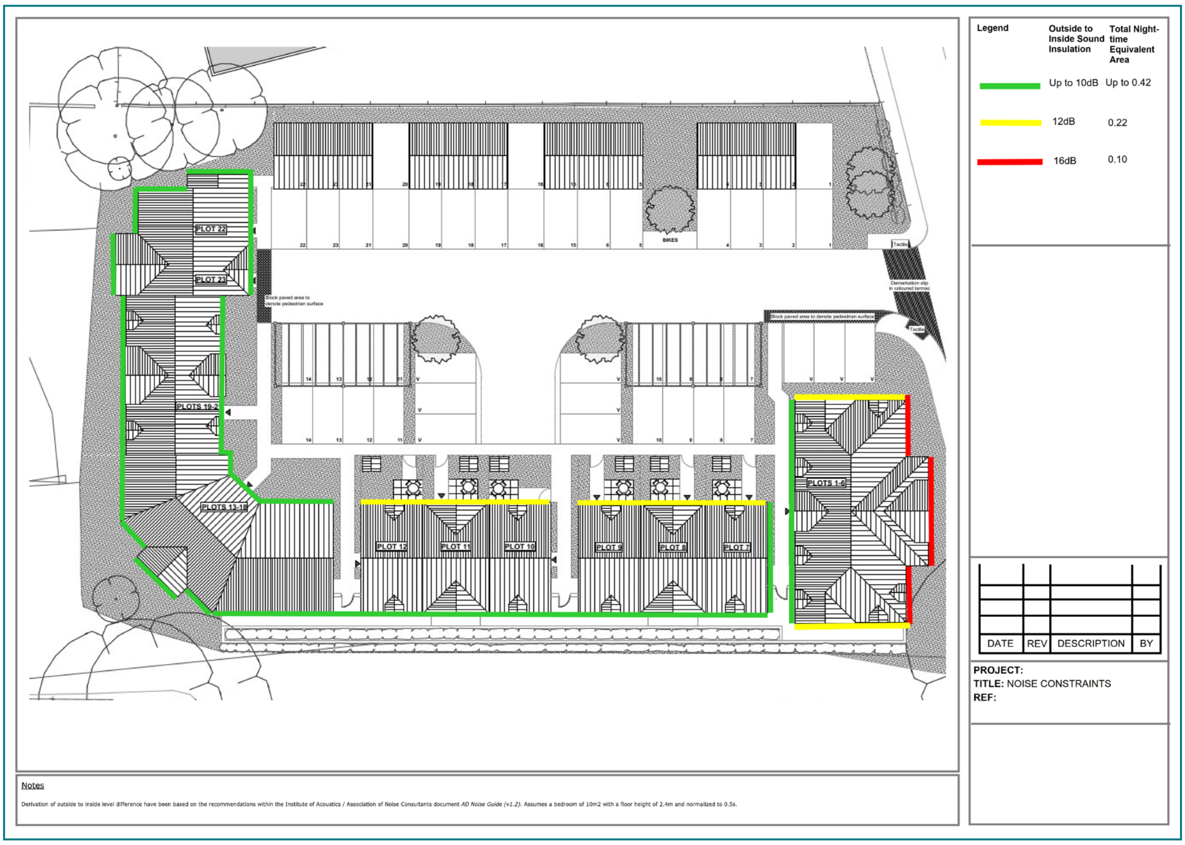
The survey results were used within a noise model to determine noise exposure across each façade.

Night-time $L_{Aeq,8h}$



10th Highest night-time $L_{AFmax,2m}$

The required level difference between free-field sound pressure levels and the AD-O noise standards was established. All bedrooms were at least 10m^2 and 2.4m ceiling height (with larger rooms providing greater outside to inside sound insulation), and from this the total night-time Equivalent Area was established.



Using equation 2, a free-field level difference of 16 dB for a bedroom of 24m^3 results in a requirement for a 0.10m^2 Equivalent Area, as shown below.

$$EA = 24 \times 10^{\left(\frac{-(16+8)}{10}\right)} = 0.10m^2$$

The calculations were repeated for each bedroom façade and the mark-up showing the required level difference and Equivalent Area was shared with the developer and dynamic thermal modeller.

Appendix C. References

Ref	Title	Author/Publisher	Year
1	Acoustics, Ventilation and Overheating: Residential Design Guide	Association of Noise Consultants / Institute of Acoustics	2020
2	Approved Document O – Overheating (2021)	The Ministry of Housing, Communities and Local Government	2021
3	National Model Design Code: Part 2 – Guidance Notes	Ministry of Housing, Communities and Local Government	2021
4	Measurement of Sound Levels in Buildings	Association of Noise Consultants	2020
5	Environmental Sound Measurement Guide	Association of Noise Consultants	2021
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	IEC 61672-1:2013 'Electroacoustics - Sound level meters - Part 1: Specifications'	International Electrotechnical Commission	2013
9	BS EN 61672-1:2013 'Electroacoustics. Sound level meters Specifications'	British Standards Institute	2013
10	Night Noise Guidelines for Europe	World Health Organization	2009
11	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	2019
12	Calculation of Road Traffic Noise	Department of Transport Welsh Office	1988

Ref	Title	Author/Publisher	Year
13	Calculation of Railway Noise	Department of Transport	1995
14	ECAC.CEAC Doc 29 4th Edition 'Report on Standard Method of Computing Noise Contours around Civil Airports. Volume 2: Technical Guide'	European Civil Aviation Conference Secretariat	2016
15	ISO 9613-2: 2024 'Acoustics — Attenuation of sound during propagation outdoors — Part 2: Engineering method for the prediction of sound pressure levels outdoors'	International Standards Organisation	1996
16	CIBSE TM59 Design methodology for the assessment of overheating risk in homes	Chartered Institute of Building Services Engineers	2017
17	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
18	Approved Document F – Ventilation, Volume 1: Dwellings (2021)	The Ministry of Housing, Communities and Local Government	2021
19	ISO/TS 19488:2021 'Acoustics — Acoustic classification of dwellings'	International Standards Organisation	2021
20	BS EN ISO 16283-3: 2016 'Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 3: Façade sound insulation'	International Standards Organisation	2016
21	Assessing noise and overheating in dwellings: aligning acoustic and thermal models for partially open windows	J Harvie-Clark, J Hill, J Batten, L Pereira, J Healey, J Howell, G Fusaro. Proc. IOA Vol. 46. Pt. 2 2024	2024
22	Directive 2002/49/EC Environmental Noise Directive	European Union	2002
23	A Guide to Measurement and Prediction of the Equivalent Continuous Sound Level Leq	The Noise Advisory Council	1978
24	Empirical relationship between L_{night} and L_{Amax}	N Conlan, W Wei, J Harvie-Clark. Proc. IOA Vol 43 Pt 1 2021	2021

APPROVED DOCUMENT O

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