BS 8233:2024 - Sound insulation and noise reduction for buildings – Guide.

Philip Dunbavin

Jack Harvie-Clark

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Background to this revision of BS 8233.

- This revision to BS 8233:2014 introduces guidance on building ventilation strategy and its impact on the facade sound insulation which was omitted from the current version and is an increasingly important aspect of sustainable and net zero carbon building design.

- It also references relevant government, World Health Organisation and industrial guidance, new and updated building regulations, along with BS 4142: 2014 + A1: 2019, all issued since the current publication of BS 8233. It also corrects a number of errors that have been identified since publication of the standard.

- Revision is required to include important policy, guidance, concepts and improved evidence that affect the acoustic design of buildings:

- National Planning Policy Framework, Noise Policy Statement for England, Planning Practice Guidance – Noise, Professional Practice Guidance on Planning and Noise;
- Health effects of noise;
- Integrated design to address the sometimes conflicting considerations of acoustics, ventilation and overheating (AVO);
- Sustainable design and net zero carbon buildings; and
- Provision for aural diversity.

The incorporation of these into the standard required significant re-structuring of the standard, including new sections to address them to an appropriate level.

Other issues:

- Clarify relationship between NR and dBA values and correct tabulated NR values;
- Clarify guidance on opening windows and trickle ventilation in respect of the building regulations;
- Clarify guidance on ‘façade’ and ‘freefield’ sound levels;
- Consider characteristics of noise, not only levels, in terms of response and disturbance;
- Revise and expand the definitions of terms; and
- Reword text on noise from industry, particularly in respect of on-site vehicle activities and relating to BS 4142.
- Also a number of typographical errors have been corrected.

Noise versus Sound.

- The principles adopted are:
- If the standard is referring to a measurement then it is sound level not noise level as a sound level meter measures sound not noise.
- In some instances a prediction may be of sound or noise and the usage is determined by the prediction method, e.g. Calculation of Road Traffic Noise, etc.
- If the standard is citing another reference or standard in which the title features the word noise this is left unchanged, e.g. Association of Noise Consultants, Code of Practice on Environmental Noise Control at Concerts, etc.
- When reference is made to human perception then noise is the correct term rather than sound.

Revised structure

0 Introduction
1 Scope
2 Normative references
3 Terms, definitions and symbols.
4 Planning considerations
5 External noise sources
6 Building design objectives
7 Sound insulation in a building
8 Sound from building services
9 Specific Types of building
10 Uncertainty
11 Sustainability

Revised structure

- Annex A Sound calculations
- Annex B Sound rating
- Annex C Specification of sound insulation
- Annex D Special problems requiring expert advice: Guidance for specific applications
- Annex E Airborne and impact sound insulation
- Annex F Legislative frame work and guidance
- Annex G Typical design problem
- Annex H Examples of design criteria adopted by hotel groups
- Annex I Measurement equipment
- Bibliography

Annexes

The annexes have had very minor corrections with the exception of Annex G – Typical design calculation.

Annex G has been completely rewritten to consider health effects it and will be covered towards the end of this presentation.

4 - Planning considerations.

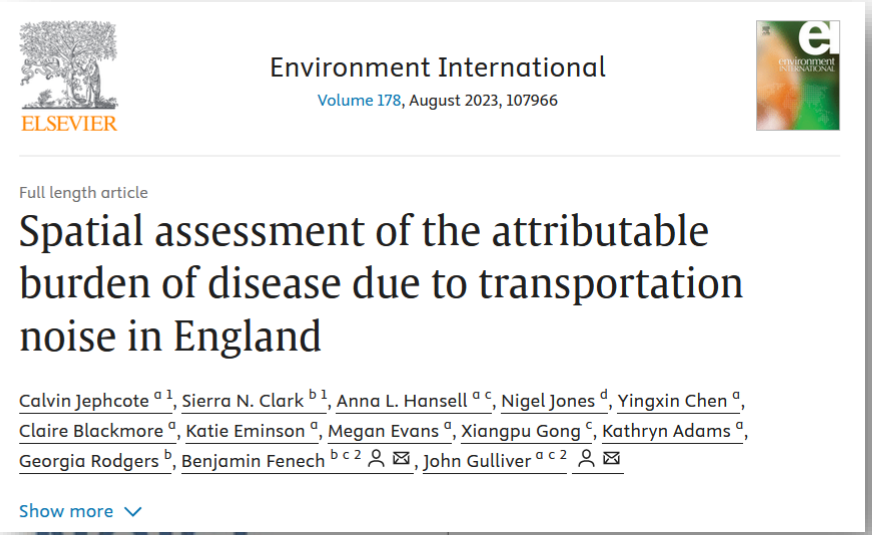
Aligning acoustic design criteria with the evidence for new residential development

Jack Harvie-Clark, Apex Acoustics

Benjamin Fenech, UK Health Security Agency

https://www.apexacoustics.co.uk/apex-at-ioa-acoustics-24-shaping-the-future-of-acoustics/

Introduction & context



ELSEVIER

Environment International

Volume 178, August 2023, 107966

Full length article

Spatial assessment of the attributable burden of disease due to transportation noise in England

Calvin Jephcote [a 1], Sierra N. Clark [b 1], Anna L. Hansell [a c], Nigel Jones [d], Yingxin Chen [a], Claire Blackmore [a], Katie Eminson [a], Megan Evans [a], Xiangpu Gong [c], Kathryn Adams [a], Georgia Rodgers [b], Benjamin Fenech [b c 2], John Gulliver [a c 2]

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Current approach

- Focus on internal sound levels for living rooms and bedrooms
- Based on WHO Guidelines for Community Noise (1999)

Table 4 **Indoor ambient noise levels for dwellings**

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq,16hour}$	—
Dining	Dining room/area	40 dB $L_{Aeq,16hour}$	—
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$

- External amenity spaces:

  ≤ 50 dB $L_{Aeq,T}$ desirable; ≤ 55 dB $L_{Aeq,T}$ upper guideline

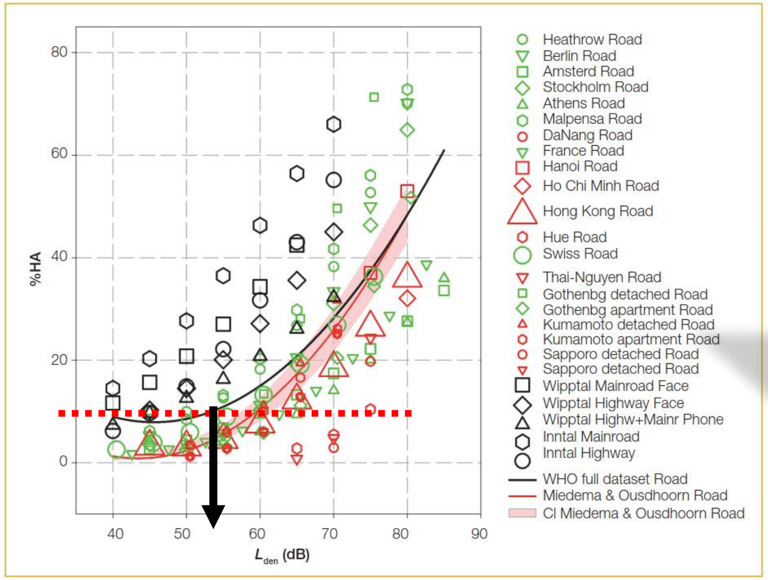
The need for change

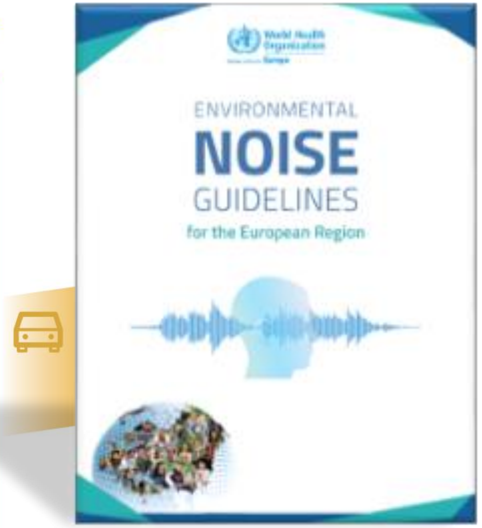
New evidence - higher levels of annoyance and sleep disturbance

Strengthening evidence of links between noise exposure and cardiovascular / metabolic diseases

WHO Environmental Noise Guidelines (2018) were a step change in epidemiological evidence synthesis

Fig. 6.Scatterplot and quadratic regression of the relationship between road traffic noise (L_{den}) and annoyance (%HA)





The need for change

- Health burden in DALYs
- L_{den} and L_{night} are primary indicators
- Conversion possible but loses information

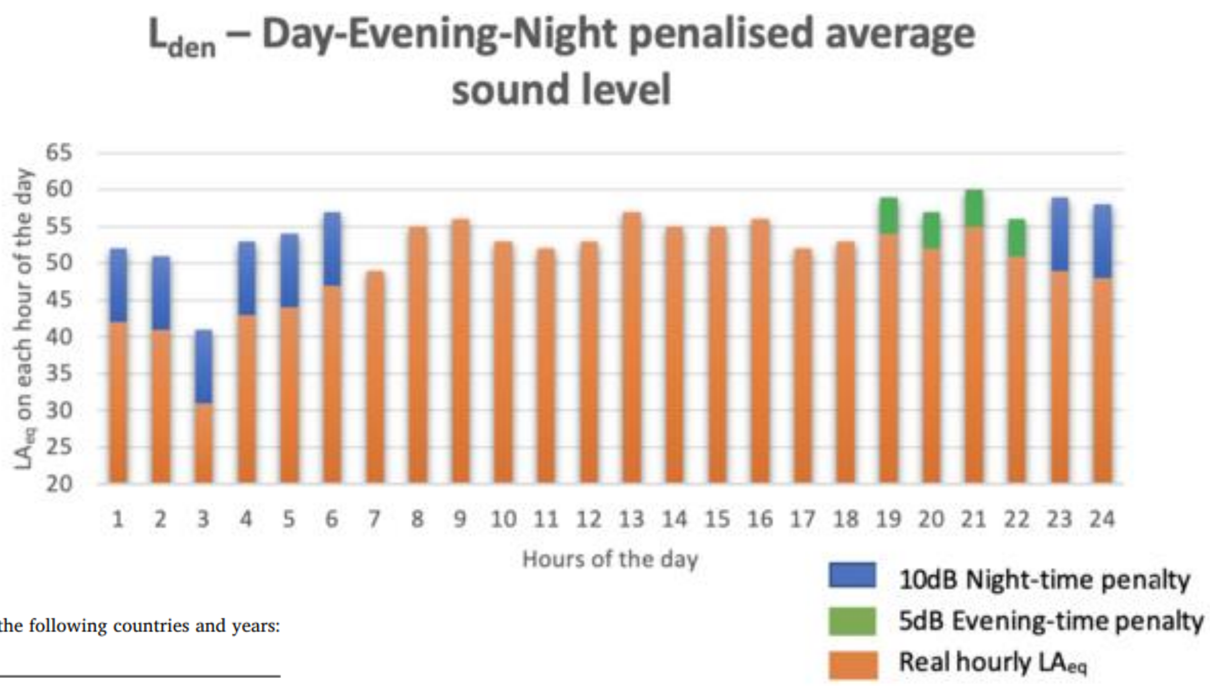


Table 2a

Average of estimated conversion terms between two different noise metrics (cp. Eqs. (1)–(7b)) for **road traffic noise**, derived from AADT data from the following countries and years: Switzerland 2011; Germany 2011, the Netherlands 2013, Belgium/Flanders 2014, the UK 2011, and France/Île-de-France 2011, in decibels [dB].

↓ Desired metric ↓	↓ Known metric ↓												
	LDay[a]	LDay[b]	LDay[c]	LNight[a]	LNight[b]	LEvening[a]	LEvening[b]	LAeq24h	Lden[a]	Lden[b]	Ldn[a]	Ldn[b]	Ldn[c]
LDay[a] =		+0.1	−0.5	+7.1	+6.0	+1.6	+2.9	+1.3	−2.0	−2.3	−2.1	−1.8	−1.3
LDay[b] =	−0.1		−0.6	+6.9	+5.9	+1.5	+2.8	+1.2	−2.1	−2.4	−2.2	−1.9	−1.4
LDay[c] =	+0.5	+0.6		+7.6	+6.5	+2.1	+3.4	+1.8	−1.5	−1.8	−1.6	−1.2	−0.8
LNight[a] =	−7.1	−6.9	−7.6		−1.1	−5.5	−4.2	−5.7	−9.1	−9.3	−9.2	−8.8	−8.3
LNight[b] =	−6.0	−5.9	−6.5	+1.1		−4.4	−3.1	−4.7	−8.0	−8.3	−8.1	−7.7	−7.3
LEvening[a] =	−1.6	−1.5	−2.1	+5.5	+4.4		+1.3	−0.3	−3.6	−3.9	−3.7	−3.4	−2.9
LEvening[b] =	−2.9	−2.8	−3.4	+4.2	+3.1	−1.3		−1.5	−4.9	−5.1	−5.0	−4.6	−4.1
LAeq24h =	−1.3	−1.2	−1.8	+5.7	+4.7	+0.3	+1.5		−3.3	−3.6	−3.4	−3.1	−2.6
Lden[a] =	+2.0	+2.1	+1.5	+9.1	+8.0	+3.6	+4.9	+3.3		−0.3	−0.1	+0.3	+0.7
Lden[b] =	+2.3	+2.4	+1.8	+9.3	+8.3	+3.9	+5.1	+3.6	+0.3		+0.2	+0.5	+1.0
Ldn[a] =	+2.1	+2.2	+1.6	+9.2	+8.1	+3.7	+5.0	+3.4	+0.1	−0.2		+0.3	+0.8
Ldn[b] =	+1.8	+1.9	+1.2	+8.8	+7.7	+3.4	+4.6	+3.1	−0.3	−0.5	−0.3		+0.5
Ldn[c] =	+1.3	+1.4	+0.8	+8.3	+7.3	+2.9	+4.1	+2.6	−0.7	−1.0	−0.8	−0.5	

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Conversion between noise exposure indicators Leq_{24h}, L_{Day}, $L_{Evening}$, L_{Night}, L_{dn} and L_{den}: Principles and practical guidance

Mark Brink[a,*], Beat Schäffer[b], Reto Pieren[b], Jean Marc Wunderli[b]

[a] Federal Office for the Environment, CH-3003 Bern, Switzerland
[b] Empa, Swiss Federal Laboratories for Materials Science and Technology, CH-8600 Dübendorf, Switzerland

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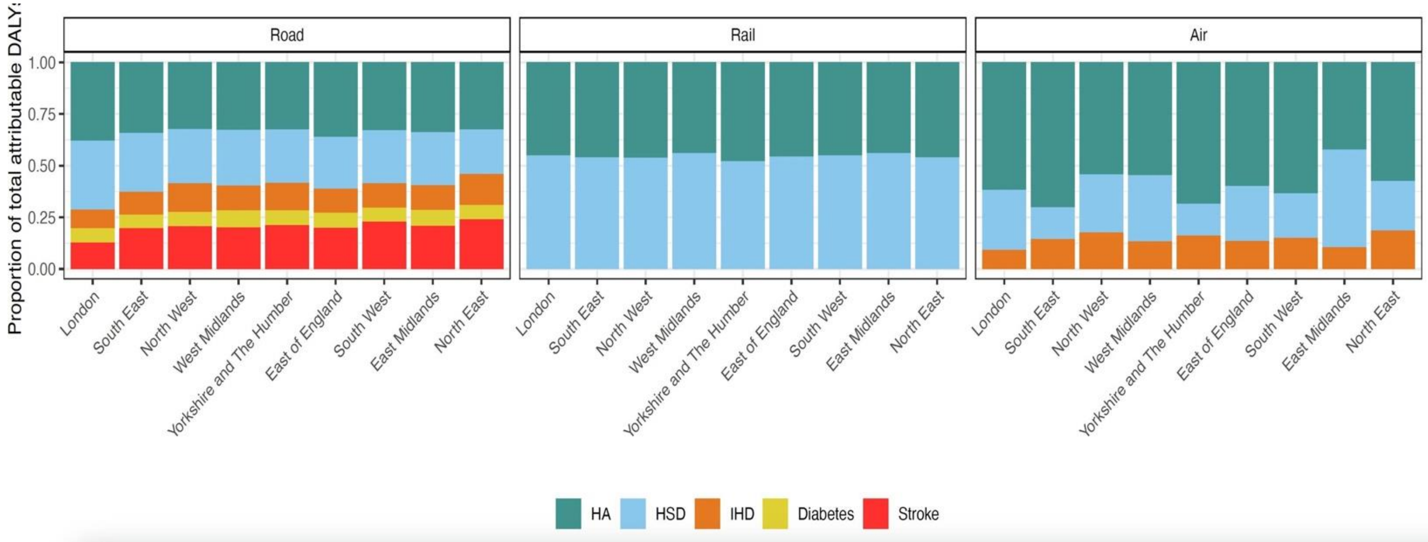
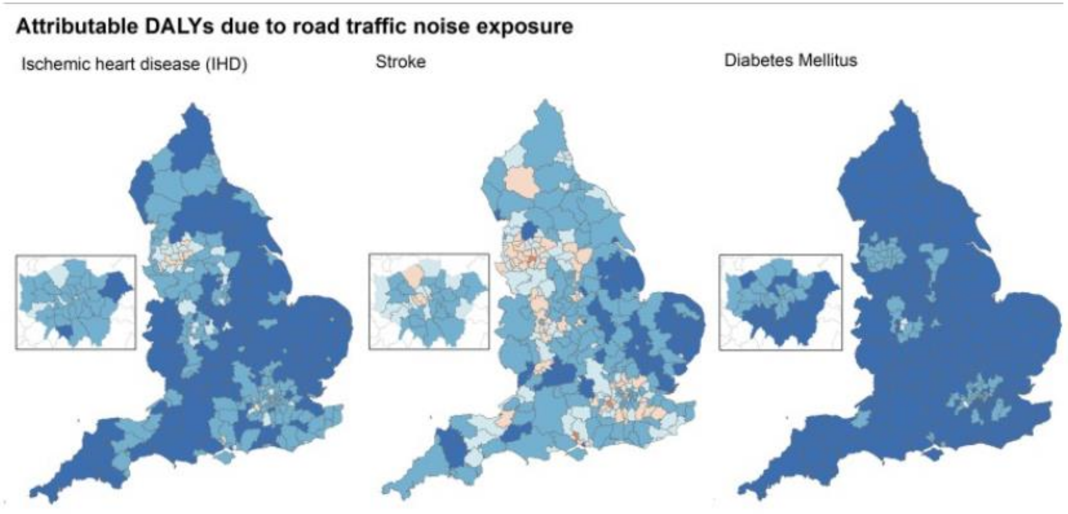
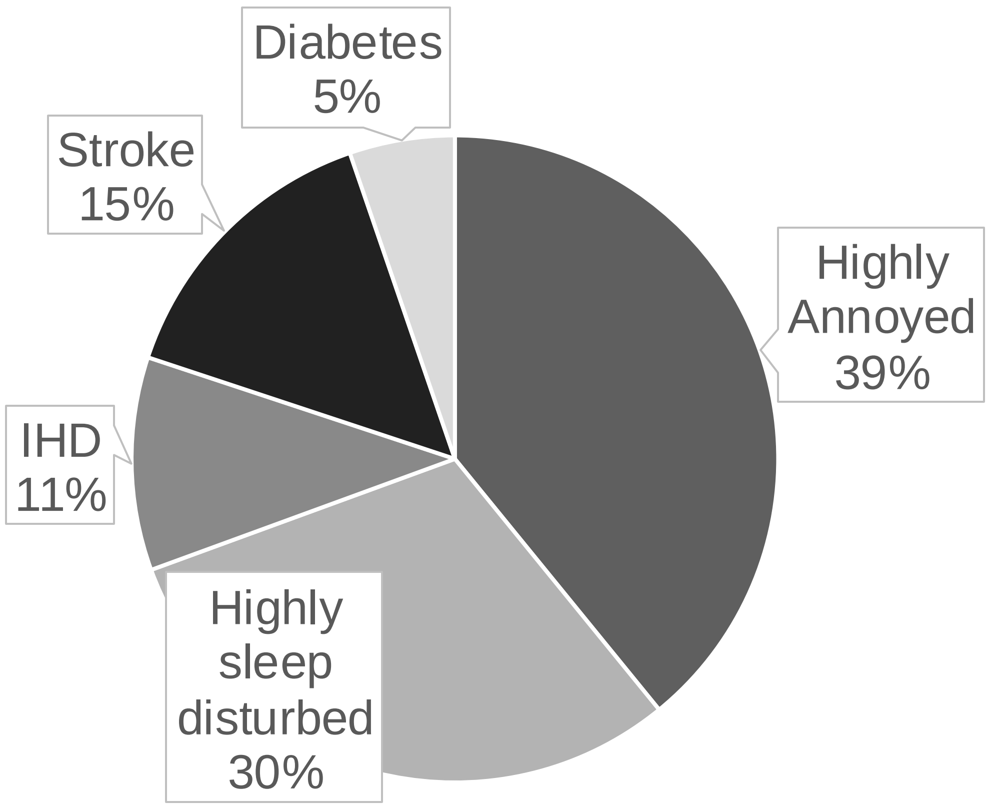
The need for change





Health effects (DALYs) by type



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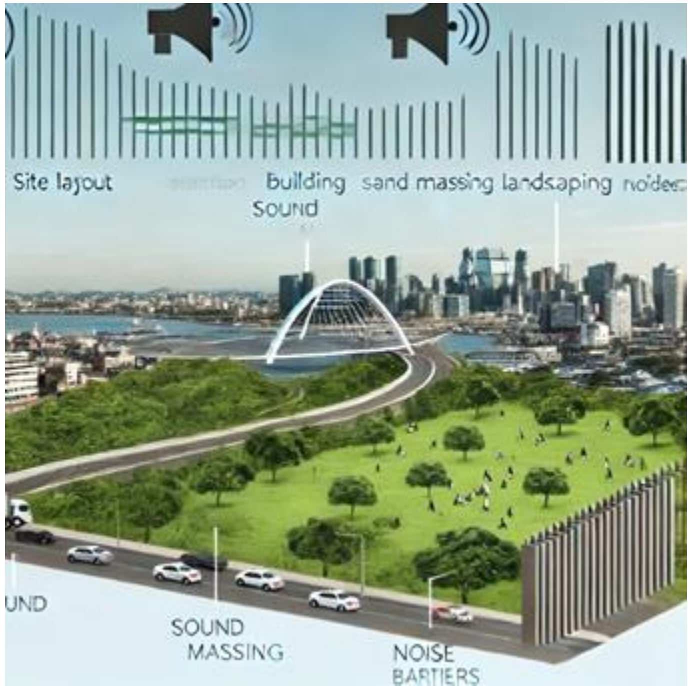
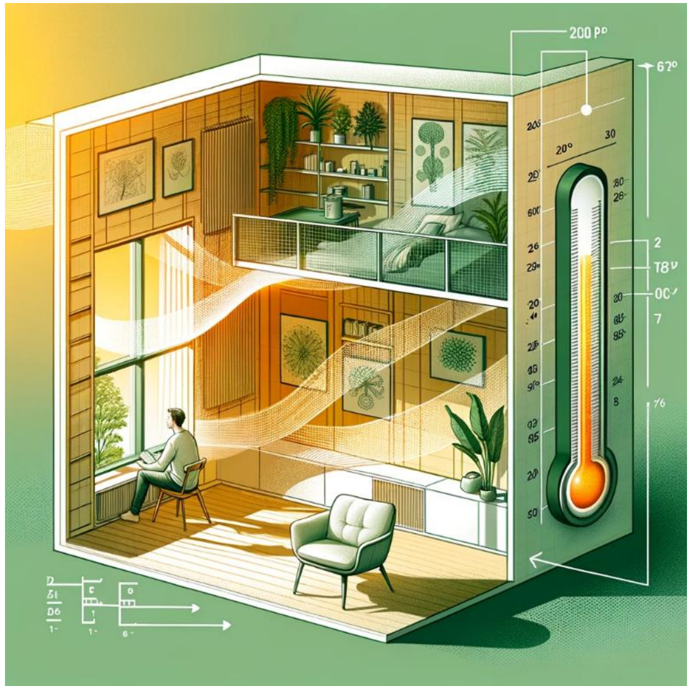
Two-Step Approach

- Step 1: External sound drives good environmental acoustic design
- Step 2: Building envelope for good internal environmental quality (IEQ)





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Step 1 - External Sound Exposure Categories (SEC)

- Five Sound Exposure Categories
- Category I: WHO 2018 criteria for setting guidelines: 10% HA and 3% HSD
- Higher categories: HA +5% increments; HSD +2% increments
- Sound levels different for road, rail, air traffic
- Categories expressed in L_{den} and L_{night}

Sound Exposure Categories

	I	II	III	IV	V
	10% ≤ 1 in 10	15% 1 in 7	20% 1 in 5	25% 1 in 4	> 25% > 1 in 4
	3% ≤1 in 33	5% 1 in 20	7% 1 in 14	9% 1 in 11	> 9% > 1 in 11

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Sound Exposure Categories

inter.noise 2022
21-24 AUGUST
SCOTTISH EVENT CAMPUS
GLASGOW

An update to the WHO 2018 Environmental Noise Guidelines exposure response relationships for annoyance from road and railway noise

Benjamin Fenech[1], Sierra Clark, Georgia Rodgers
Noise and Public Health team, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, United Kingdom

ABSTRACT
The systematic review on environmental noise and annoyance commissioned by the World Health

Review

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP10197.

Environmental Noise and Effects on Sleep: An Update to the WHO Systematic Review and Meta-Analysis

Michael G. Smith,[1] Makayla Cordoza,[1] and Mathias Basner[1]*

[1]Unit for Experimental Psychiatry, Division of Sleep and Chronobiology, Department of Psychiatry, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA

MDPI

Review

WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance

Rainer Guski [1,*], Dirk Schreckenberg [2] and Rudolf Schuemer [3]

1 Department of Psychology, Ruhr-University Bochum, 44801 Bochum, Germany
2 ZEUS GmbH, Zentrum für Angewandte Psychologie, Umwelt- und Sozialforschung, Sennbrink 46, 58093 Hagen, Germany; schreckenberg@zeusgmbh.de
3 Independent Researcher, 58095 Hagen, Germany; ar-schuemer@t-online.de
* Correspondence: rainer.guski@ruhr-uni-bochum.de

Received: 26 July 2017; Accepted: 23 November 2017; Published: 8 December 2017

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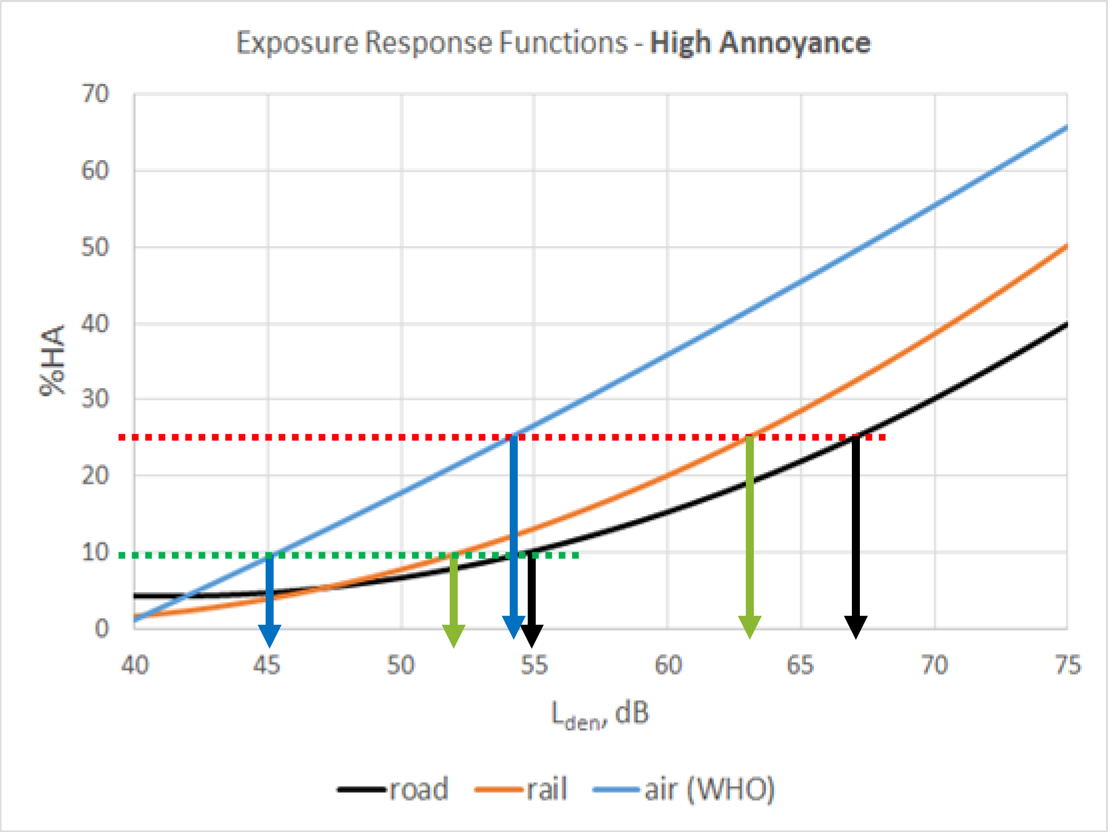
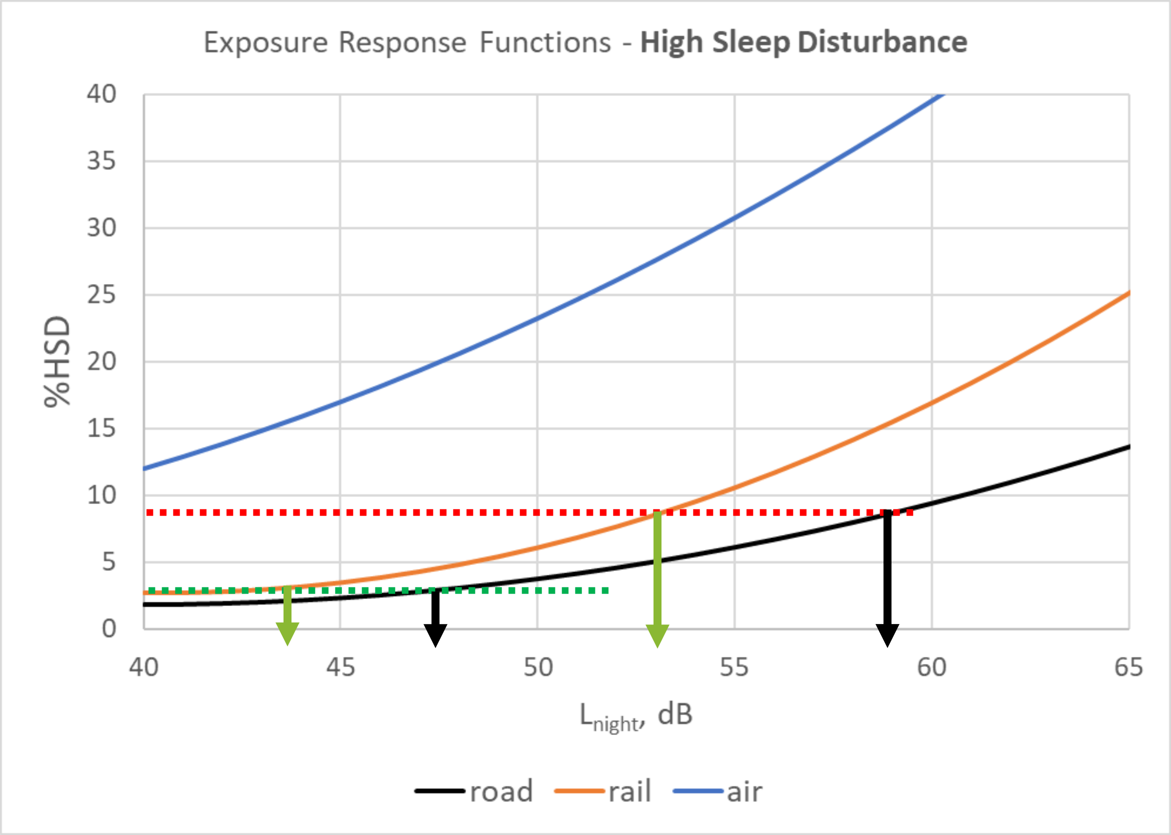
Sound Exposure Categories





* Thresholds for aircraft noise can be updated once results from UK-based primary research and secondary analysis are published.

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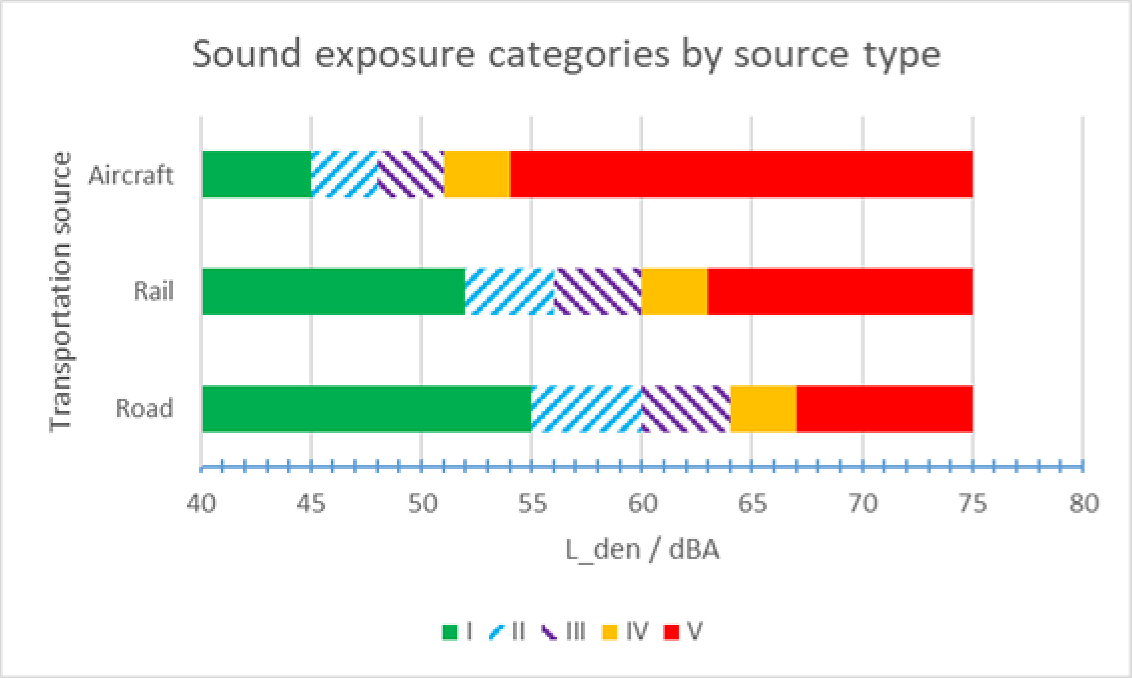
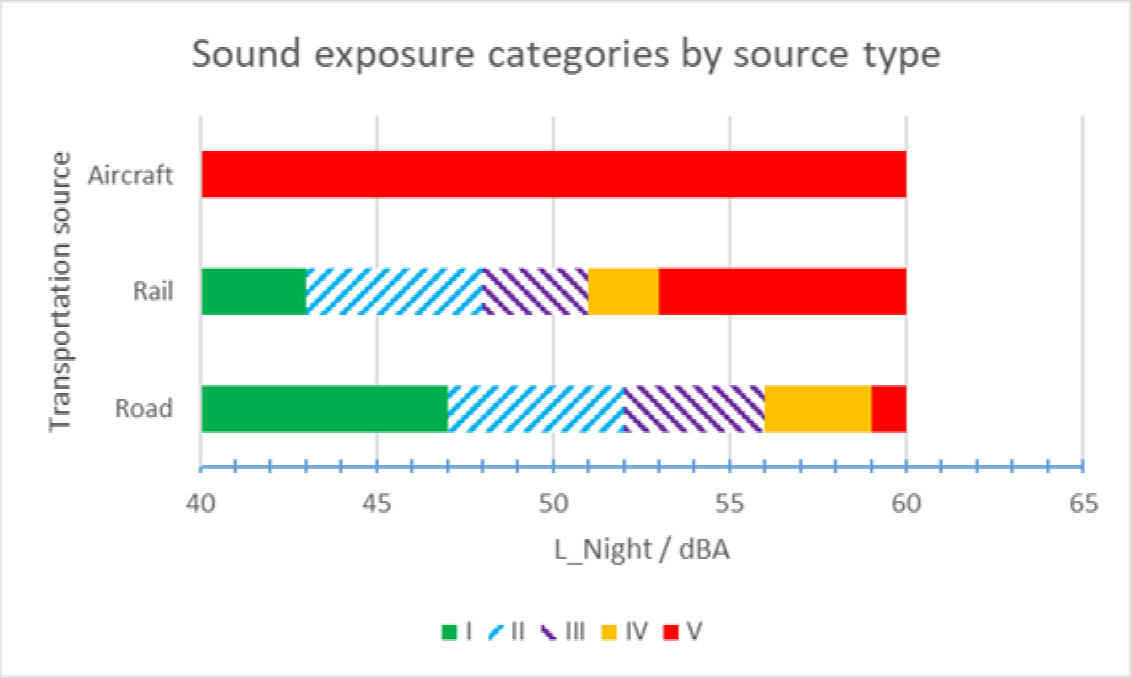
Sound Exposure Categories

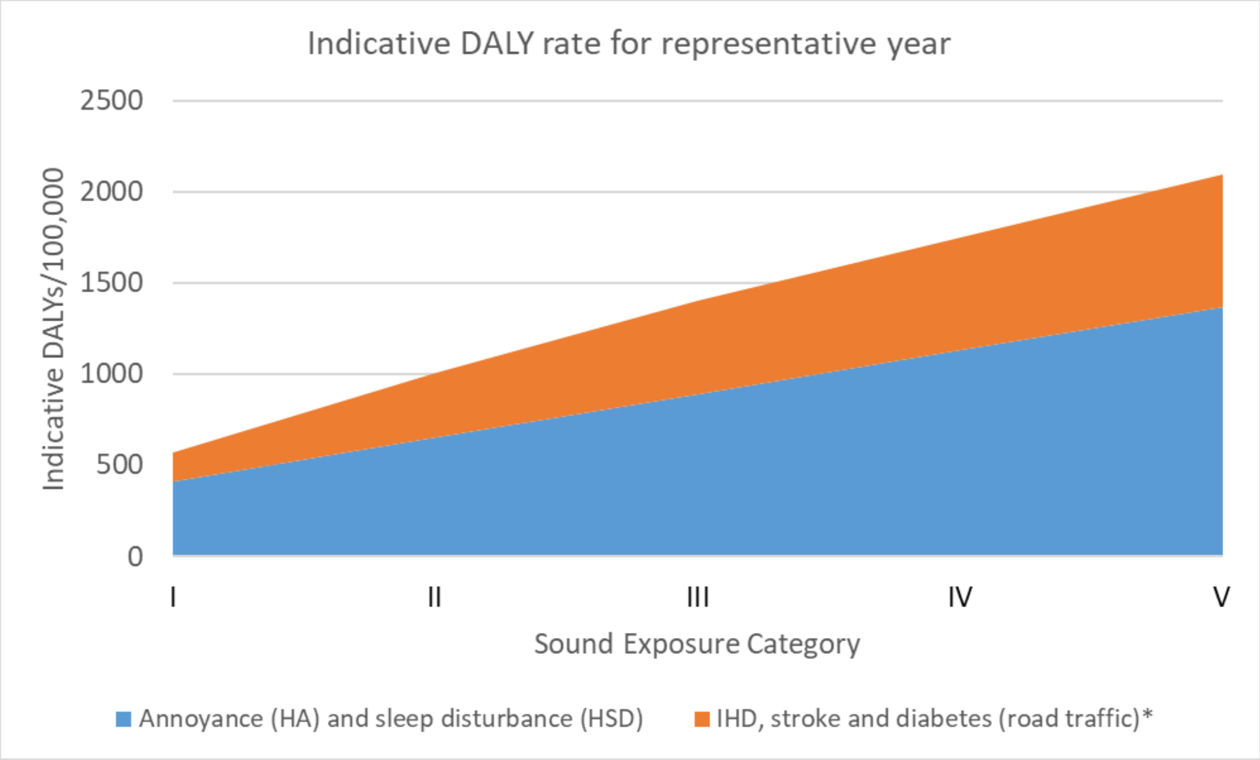


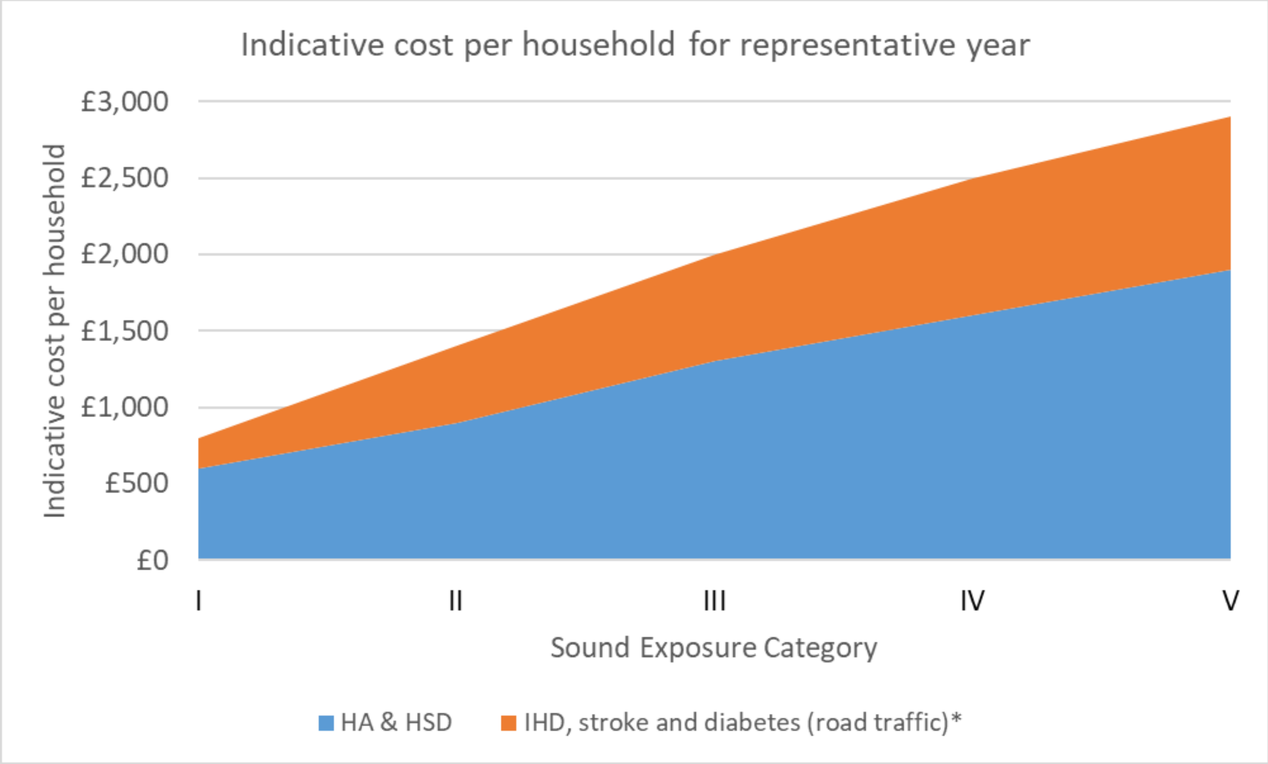


Health Impacts and Costs

- Residential development in areas with high noise exposure has a cost burden on society - market and non-market costs
- Understanding this cost can lead to better decision making
- DALYs (Disability Adjusted Life Years) used to quantify health burden
- Annoyance and sleep disturbance: DALYs per 100,000 population/ year
- IHD, stroke, diabetes: estimate using IHME GBD 2019 data: DALYs per 100,000 population for representative year
- Indicative costs per household calculated assuming 1 DALY = £60,000

Health Impacts and Costs

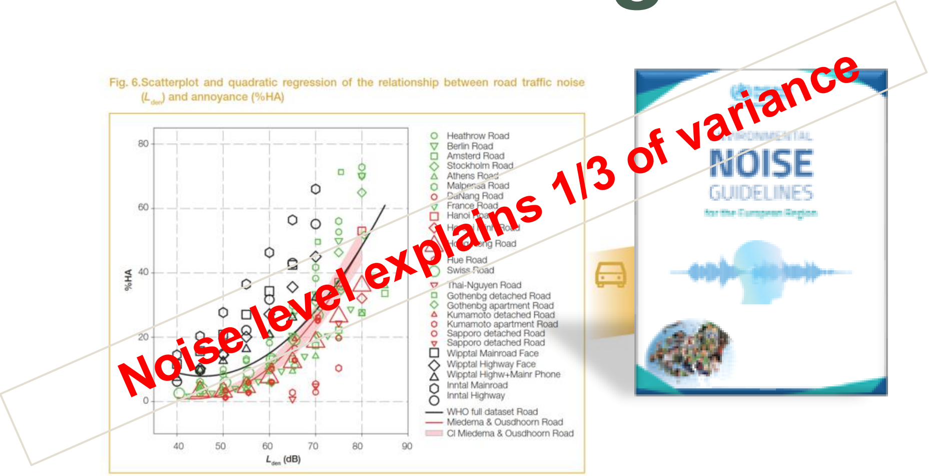




- Estimates based on IHME GBD 2019 data. England averaged data.
- **Values for regions with highest disease burdens were ~30% higher.**

SECs - Good Environmental Acoustic Design

- Plentiful land supply
  - restrict categories
- Limited land supply
  - allow higher categories
- **Require non-acoustic factors to be taken into account**



- Non-acoustic factors:
  - Personal
  - Situational
  - Local Environment
  - Social

Proceedings of the Institute of Acoustics

A DRAFT CONCEPTUAL FRAMEWORK FOR A NEW INTERNATIONAL TECHNICAL STANDARD ON NON-ACOUSTIC FACTORS

L Woodland	UK Health Security Agency, London, UK
J Chieng	UK Health Security Agency, London, UK
B Fenech	UK Health Security Agency, London, UK
L Lavia	Noise Abatement Society, Brighton and Hove, UK
F Aletta	University College London, UK
J Kang	University College London, UK
A Mitchell	University College London, UK

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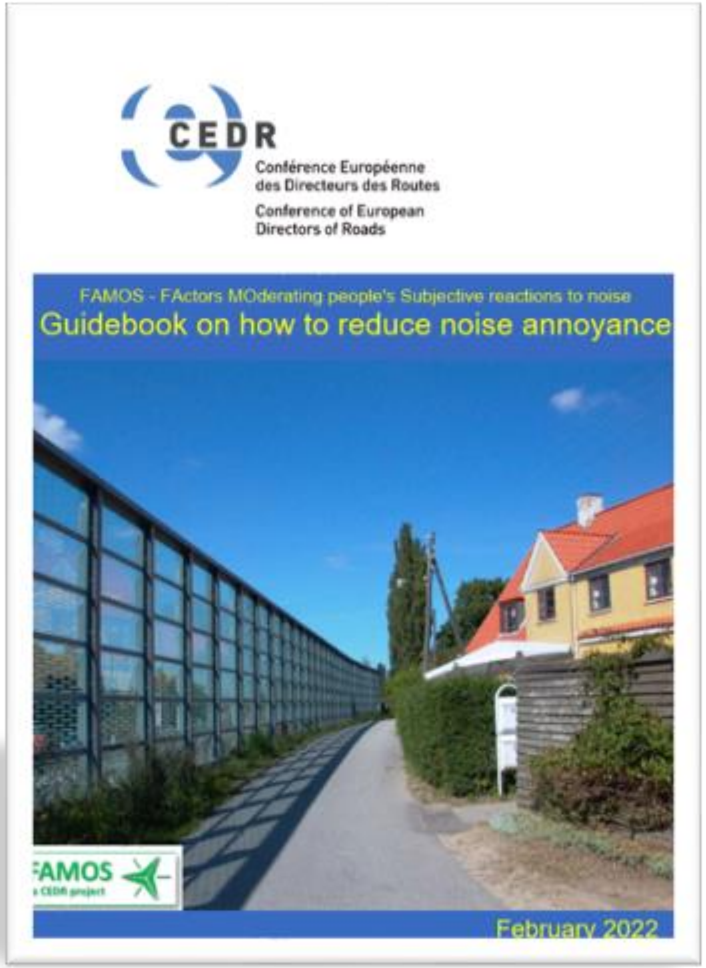
Using non-acoustic factors – FAMOS Project

- **FA**ctors **MO**derating people's **S**ubjective reactions to noise

The aim of this research programme is to reduce noise exposure and noise nuisance for people living near national roads, and to identify methods that could improve the way noise is perceived by these people



https://www.cedr.eu/peb-research-programme-2018-noise-and-nuisance

FAMOS Project

..effects are not simple to combine for different moderators

Moderator	Effect size
Trust / acceptance	±10 dB
Expectations met	5 to 10 dB
Access to silent side	6 to 9 dB
Low/no visibility of the road	2 to 10 dB
Increased traffic volume	~1.5 dB per doubling
Neighbourhood noise	up to 10 dB
Orientation of outdoor areas	8 to 12 dB
Traffic safety expectations	5 to 8 dB
Vegetation and greenery	6 to 10 dB
Visual appearance of the barrier	2 dB

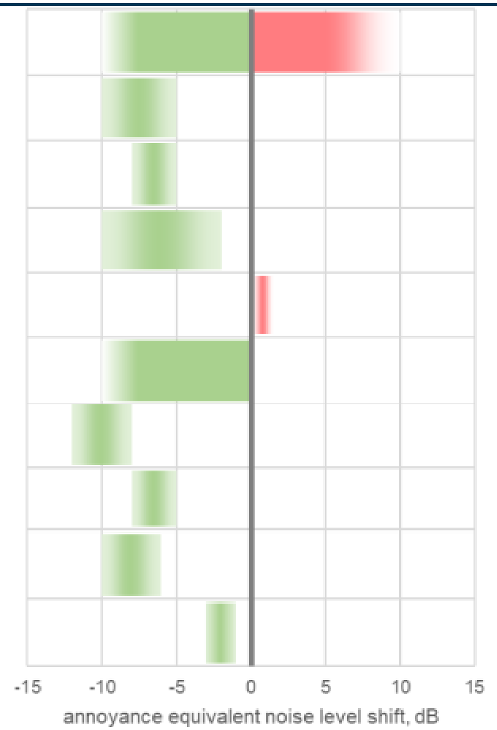


Figure 33: Overview on moderator effect sizes

https://www.cedr.eu/peb-research-programme-2018-noise-and-nuisance

Step 2 - Internal sound levels

- Consider provisions for ventilation (IAQ)
- Consider provisions for thermal comfort
- Option 1: Retain current internal levels
- Option 2: Align with ISO/TS 19488 – $D_{nT,\mathrm{A,tr}}$
- Option 3: Additional analysis on physiological awakenings for L_{max}

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Façade sound insulation

Transportation type	Façade sound insulation, $D_{nT,A,tr}$ / dB
Road traffic	≥ L_{den} - 32

$D_{nT,A,tr}$ ≥ 30 dB

Sound Exposure Category	Façade sound insulation, $D_{nT,A,tr}$ / dB				
	I	II	III	IV	V*
Road traffic	≥ 30	≥ 30	≥ 32	≥ 35	≥ L_{den} - 32
Railway traffic					≥ L_{den} - 28
Air traffic					≥ L_{den} - 19

* Minimum value in SEC V is 35 dB $D_{nT,A,tr}$

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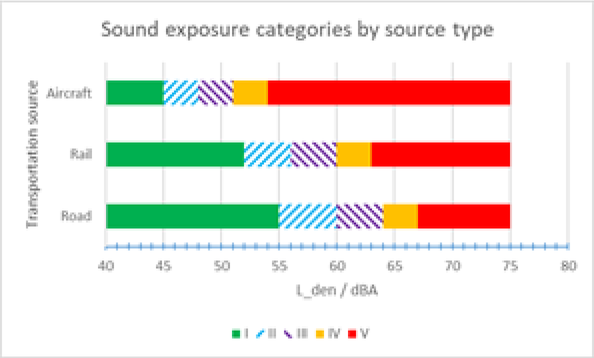
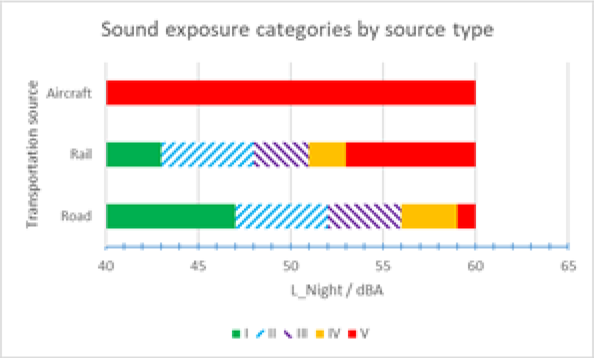
Mitigating overheating

Sound Exposure Category (SEC)	**I**	**II**	**III**	**IV**	**V**
Daytime provisions (L_{den} SEC)	Opening windows				
Nighttime provisions (L_{night} SEC)				Closed windows	

Worked example - site assessment & facade

Aspect	Dominant source	L_{den} / dB	L_{night} / dB
Façade A	Road	57	49
Façade B	Railway	57	53





Sound Exposure Category	Façade sound insulation, $D_{nT,A,tr}$ / dB				
	I	II	III	IV	V*
Road traffic	≥ 30	≥ 30	≥ 32	≥ 35	≥ L_{den} - 32
Railway traffic					≥ L_{den} - 28
Air traffic					≥ L_{den} - 19

Aspect	Dominant source	L_{den} SEC	L_{night} SEC	$D_{nT,A,tr}$ / dB
Façade A	Road	II	II	30
Façade B	Railway	III	IV	35

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Worked example - mitigating overheating

Aspect	Dominant source	L_{den} SEC	L_{night} SEC
Façade A	Road	II	II
Façade B	Railway	III	IV

Sound Exposure Category (SEC)	I	II	III	IV	V
Daytime provisions (L_{den} SEC)	Opening windows				
Nighttime provisions (L_{night} SEC)			Closed windows		

Facade A

Opening windows in daytime

Detailed assessment for night time

Facade B

Detailed assessment in daytime

Closed windows for night time

Implementation challenges

- Balancing acoustics vs sustainable development objectives
- Competing priorities: housing density, £££, urban design, building layout
- Integrating noise considerations in mixed-use developments
- Providing quiet outdoor amenity spaces in noisy environments
- Quantifying health and social costs

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Future research needs

- Strengthen evidence base for internal sound criteria
- Investigate relationship between short-term awakenings and long-term health outcomes
- Practical methodologies for noise from events, L_{max}
- Effectiveness of non-acoustic factors in mitigation
- Cost-benefit analysis of noise mitigation measures
- Interdependencies of indoor air quality, temperature and noise & associated health impacts

Conclusions and next steps

- Acoustic design driven by health evidence
- Balances health protection with practical development constraints
- Holistic approach to IEQ
- Next steps:
  - Consultation – est. mid-November
  - Refinement of proposals

Summary of proposed changes

Existing guidance

- Internal level guidelines
- $L_{Aeq, 16 hr}$, $L_{Aeq, 8 hr}$
- GAD by internal levels
- Façade SI based on internal levels
- Noise from events, L_{max}
- AVO assessment for overheating
- Approved Doc O in England
- External amenity area guidelines

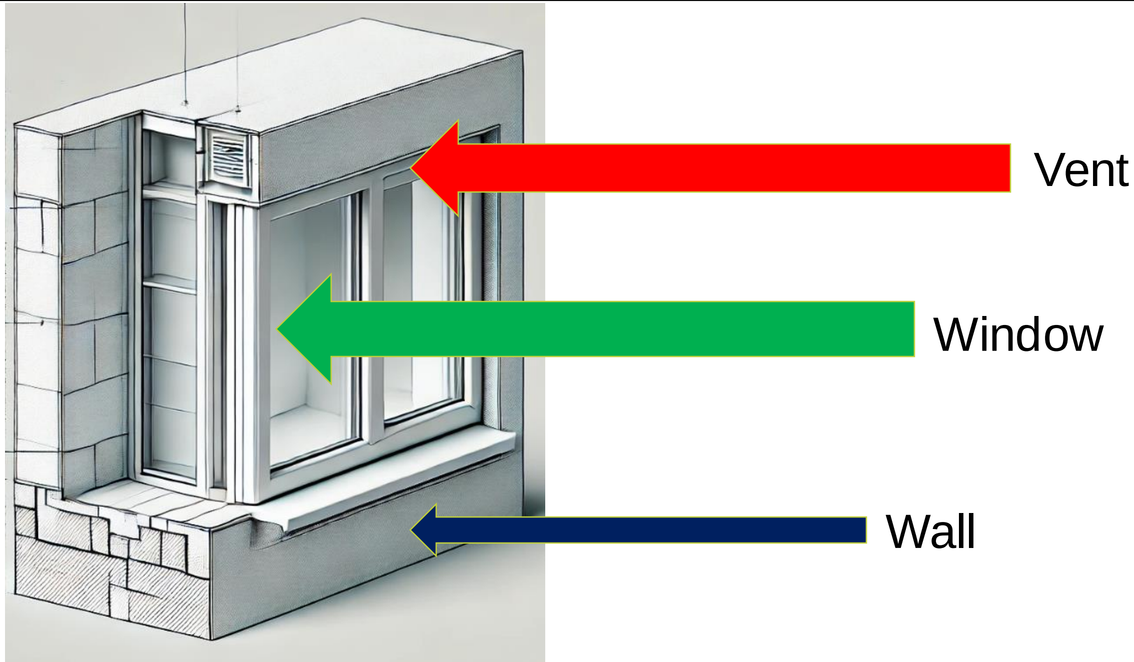
Proposed

- External Sound Exposure Categories
- L_{den}, L_{night}
- GEAD driven by health evidence
- Façade sound insulation, $D_{nT, A, tr}$
- Categories account for L_{max} events
- Simpler approach with SECs
- Approved Doc O in England
- SECs replace fixed external amenity guidelines

Annex G1 – Calculating façade levels

$$L_{eq,2} = L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3 \qquad (G.1)$$

$$Partial\ L_{eq,2} = L_{eq,ff} \qquad (\qquad -R \quad ew \qquad) \qquad + 10\log\left(\frac{S}{A}\right) + 3$$



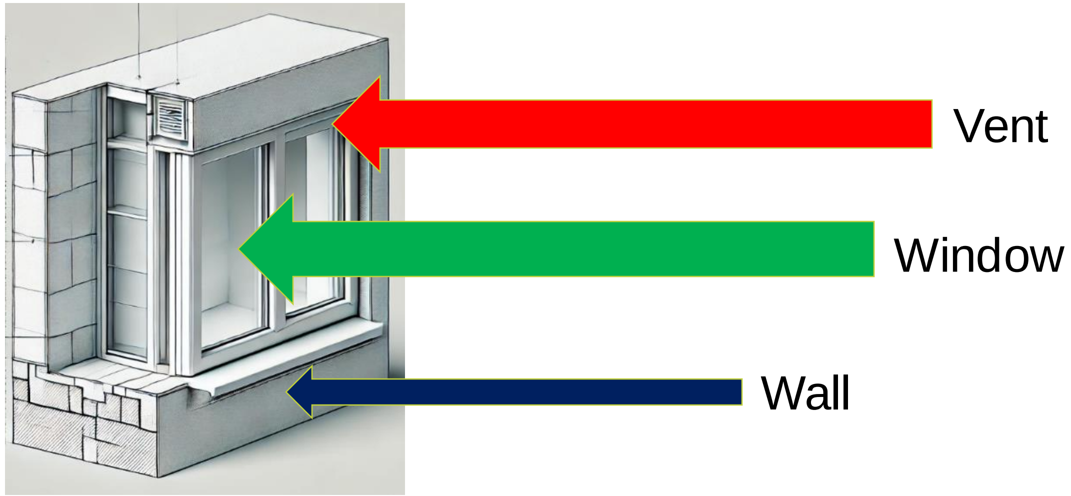
Annex G1 – Calculating façade levels

$$Partial\ L_{eq,2,nT} = L_{1,2m} - R + 10\log\left(\frac{T_0 * S}{0.16 * V}\right)$$

$$Partial\ L_{eq,2,nT} = L_{1,2m} - R + 10.\lg\left(\frac{S}{V}\right) + 5$$

$$Partial\ L_{eq,2,nT} = L_{1,2m} - R + 10.\lg\left(\frac{S}{V}\right) + 5$$

$$Partial\ L_{eq,2,nT} = L_{1,2m} - D_{n,e} + 10.\lg\left(\frac{N_{vent}}{V}\right) + 15$$

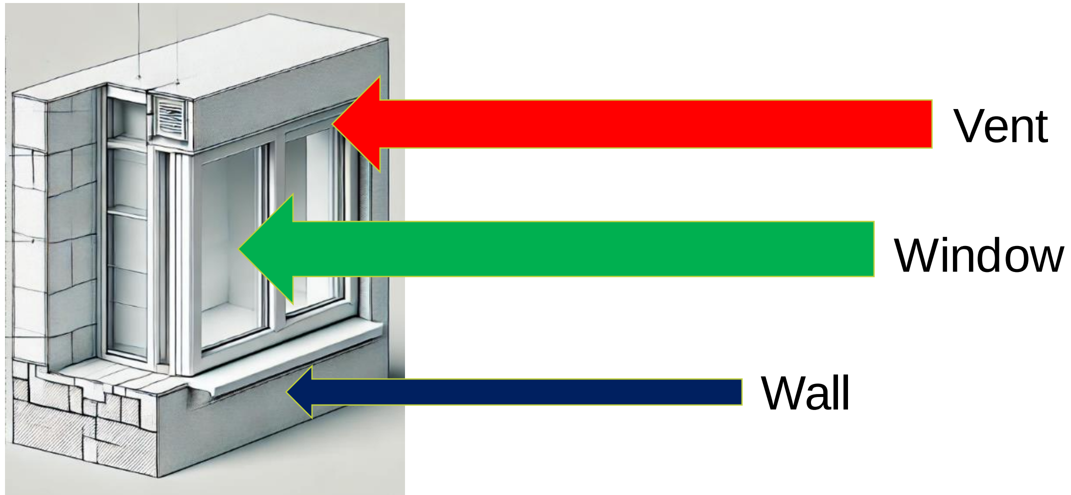


Annex G2 – Calculating façade level difference

$$Surface\ \boldsymbol{Partial}\ \boldsymbol{D_{2m,nT,A,tr}} = L_{1,2m} - Partial\ L_{eq,2,nT} = \boldsymbol{R_w} + \boldsymbol{C_{tr}} + \mathbf{10.\,lg}\left(\frac{\boldsymbol{V}}{\boldsymbol{S}}\right) - \mathbf{5}$$

$$Element\ Partial\ D_{2\mathrm{m,n}T,\mathrm{A,tr}} = \boldsymbol{D_{\mathbf{n,e,w}}} + \boldsymbol{C_{\mathbf{tr}}} + \mathbf{10.\,lg}\left(\frac{\boldsymbol{V}}{\boldsymbol{N}}\right) - \mathbf{15}$$

$$\boldsymbol{D}_{\mathbf{global}} = -\mathbf{10}\,\mathbf{log}\left(\mathbf{10}^{\left(-\boldsymbol{D}_{\mathbf{partial,1}}/\mathbf{10}\right)} + \ldots + \mathbf{10}^{\left(-\boldsymbol{D}_{\mathbf{partial,}\boldsymbol{n}}/\mathbf{10}\right)}\right)$$



Annex G2 – Calculating façade level difference

$$Surface\ \mathbf{Partial}\ D_{2m,nT,A,tr} = R_w + C_{tr} + 10.\lg\left(\frac{V}{S}\right) - 5$$

$$Element\ Partial\ D_{2m,nT,A,tr} = D_{n,e,w} + C_{tr} + 10.\lg\left(\frac{V}{N}\right) - 15$$

$$D_{global} = -10\log\left(10^{(-D_{partial,1}/10)} + \ldots + 10^{(-D_{partial,n}/10)}\right)$$

Room element	V / m³	S / m² (or N)	R, $D_{n,e..}$ + C_{tr}/ dB	Partial $D_{2m,nT,A,tr}$ / dB
Wall	26.4	5.8	45	46.6
Window	26.4	1.4	26	33.8
Vent	26.4	1	34	33.2
Global level difference, $D_{2m,nT,A,tr}$ = 30.4 dB				

Questions for you! Do you agree:

- We need a half day workshop to understand the proposed changes
- Acoustic design drivers should align with the health evidence
- The proposed approach is sufficiently aligned but practical to implement
- We need more detail for façade sound insulation for sources with different spectral content
- We can derive evidence-based internal targets
- Assessment of opening windows to mitigate overheating is too simplistic

When you press “submit”, please follow the next link to write your questions

Sound insulation matrix (dB $D_{nT,w}$)

Table 3 Example on-site sound insulation matrix (dB $D_{nT,w}$)

Privacy requirement	Activity noise of source room	Noise sensitivity of receiving rooms		
		Low sensitivity	Medium sensitivity	Sensitive
Confidential	Very high	47	52	57 [A)]
	High	47	47	52
	Typical	47	47	47
	Low	42	42	47
Moderate	Very high	47	52	57 [A)]
	High	37	42	47
	Typical	37	37	42
	Low	No rating	No rating	37
Not private	Very high	47	52	57 [A)]
	High	37	42	47
	Typical	No rating	37	42
	Low	No rating	No rating	37

NOTE Background noise can also influence privacy. See also ***7.7.6.3***.

[A)] $D_{nT,w}$ 55 dB or greater is difficult to obtain on site and room adjacencies requiring these levels should be avoided wherever practical.

7 – Sound insulation in a building

- Signposting to
  - Approved Doc E
  - HTM 08-01
  - Building Bulletin 93
  - Cinemas

Adjacency	**Minimum standardised sound level difference, (dB $D_{nT,w}$)**
Auditorium to Auditorium	65 (and 35 dB $D_{nT,63Hz}$)
Auditorium to Foyer	60
Auditorium to Concourse / Projection Level	55
Auditorium to Undercroft / WC / Offices	45

Offices & meeting rooms

- Privacy factor, $PF = D_{nT,w} + NR$
- Assume steady state background of NR 30, or 35 dB $L_{Aeq,\,T}$, then for **Speech Privacy**:

Privacy category	Privacy description	Min. dB $D_{nT,\,w}$	Comments	Assumed PF
A	Highly confidential	50	Loud speech typically barely audible	80
B	Confidential	45	Loud speech typically audible but not intelligible Raised speech typically barely audible	75
C	Moderate privacy	40	Raised speech typically audible but not intelligible Normal speech typically barely audible	70
D	Low privacy	35	Raised speech potentially intelligible Normal speech typically audible but not intelligible	65
N/C	None	<35	Normal speech typically intelligible	-

Furniture elements

- ISO 23351-1:2020 is a test method for speech reduction performance of a standalone furniture item
- Suitable speech privacy can be achieved when the $D_{S,A}$ + ambient L_{Aeq} ≥ 60 dB
- **Enclosed phone booths** - achieve Speech privacy Class B, ≥ 25 dB $D_{S,A}$
- **Enclosed meeting room pods** achieve Speech privacy Class A, ≥ 30 dB $D_{S,A}$.

Podcast room adjacency	**Minimum standardised sound level difference, range, (dB $D_{nT,w}$)**
Podcast room front into a corridor	35 - 40
Podcast room front into open plan office	45 - 50
Podcast to adjacent cellular space	50 - 55
Podcast to control room / editing suite directly associated with podcast room containing glazed element	45 - 50

Example sound insulation matrix (dB $D_{nT,w}$)

Activity sound of source room	Noise sensitivity of receiving rooms		
	Low sensitivity	Medium sensitivity	Sensitive
Very high	45	50	55 A)
High	35	40	45
Typical	30	35	40
Low	No rating	30	35

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Control of reverberant sound – current text

7.6 Limits for reverberation time

As well as internal ambient noise level, the reverberation time, *T*, measured in seconds (s), should also be considered because it affects the noise level in the space, and also affect
where good speech c
reverberation time ac
of public address ann

7.7.10.3 Design for good speech communication

The sound that arrives at the listener's ears can be considered to have the following three components.

General guidance on designing
in **7.7.10**, although the acoustic
beyond the scope of this British

The optimum values for reverberation time also vary with frequency (pitch) of the sound. Guide values of *T* for rooms of different volume can be found in standard texts, e.g. *Noise control in building services* [28]. Guidance on the calculation of reverberation time in enclosed spaces generally is given in BS EN 12354-6, while BS EN ISO 3382-2 gives guidance for calculation in ordinary rooms and BS EN ISO 3382-1 gives guidance for calculation in larger (performance) spaces.

[28] SOUND RESEARCH LABORATORIES LTD. *Noise control in building services.* Oxford: Pergamon Press. 1988.

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Control of reverberant sound

- Buildings should be designed to suit a wide range of people …
- **… with a specific focus on reducing health inequalities…**
- Control the build-up of reverberant sound from the occupants' activities
- What do others do?
  - German DIN 18041
  - Approved Doc E guidance for circulation areas
  - ISO/TS 19488 Acoustic classification scheme for dwellings
  - Italian Standard UNI 11532:2020
  - Norwegian standard NS 8175
  - ISO 23591:2021 Acoustic quality criteria for music rehearsal rooms and spaces

Control of reverberant sound

- What do others do? Variously present requirements for:

  - sound absorption per unit volume of space, A/V (Sabines / m^{3})
  - Reverberation time, T (s)
  - Reverberation time as a function of room height, T_h (s)
  - Mean sound absorption coefficient, $\bar{\alpha}$
  - $T = 0.16 * \frac{V}{A}$?

Control of reverberant sound

- $T = 0.16 * \frac{V}{A}$

$$A = \sum_{i=1}^{n} \alpha_{s,i} S_i + \sum_{j=1}^{o} A_{obj,j} + \sum_{k=1}^{p} \alpha_{s,k} S_k + A_{air}$$

$$A_{obj} = V_{obj}^{2/3}$$

BRITISH STANDARD

BS EN 12354-6:2003

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

Part 6: Sound absorption in enclosed spaces

4.4 Determination of reverberation time

The reverberation time is determined from the total equivalent sound absorption area, as calculated by 4.3, the volume of the empty enclosed space and the object fraction:

$$T = \frac{55,3}{c_o} \frac{V(1-\Psi)}{A}$$

where

c_o is the speed of sound in air, in metres per second.

NOTE For the ratio $55,3/c_o$ to be 0,16 as assumed in EN ISO 140-4 [8] the speed of sound has to be taken as 345,6 m/s.

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DIN 18041

Datum:2016 März

DIN 18041

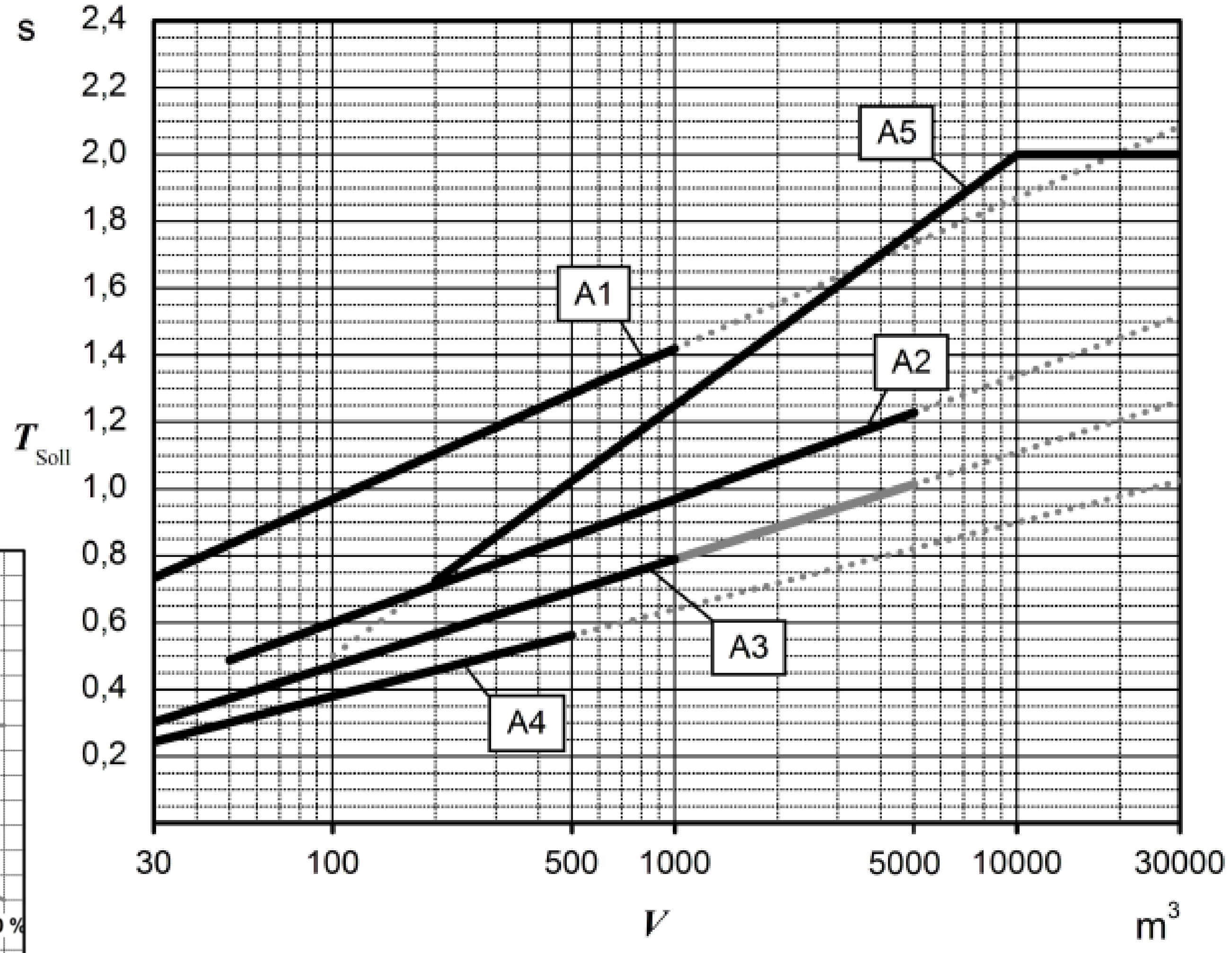
Hörsamkeit in Räumen — Anforderungen, Empfehlungen und Hinweise für die Planung

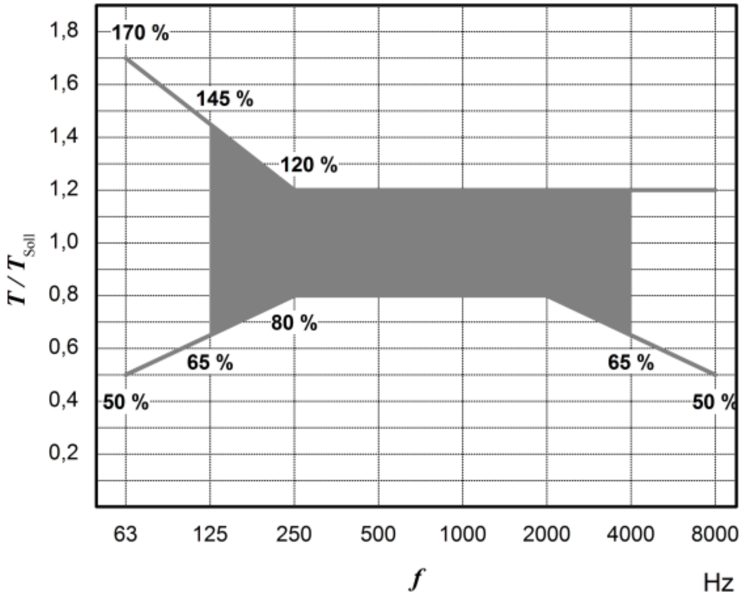
Acoustic quality in rooms — Specifications and instructions for the room acoustic design

Qualité acoustique dans les salles — Spécifications et instructions pour la planification

DIN 18041 – Group A

- Group A – primarily speech, music
- A1: Music
- A2: Speech/Presentation
- A3: Education/Communication
- A4: Education/Communication inclusive
- A5: Sport





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DIN 18041 – Group B

Usage Type	Description	Examples
B1	Rooms without quality of stay	Entrance halls, corridors, stairwells and similar as mere traffic areas
B2	Rooms for short term lingering	Entrance halls, hallways, staircases and similar circulation. Traffic areas where people may need to congregate or wait for appreciable periods
B3	Rooms for fairly long-term lingering	Exhibition rooms, waiting rooms, dining areas, canteens, libraries
B4	Rooms with a need for noise reduction and room comfort	Reception/counter area, laboratories, residential rooms in care facilities, public offices
B5	Rooms with a specific demand for noise reduction and room comfort	Dining areas and canteens in schools, child day care facilities, hospitals and care facilities, Working space with particularly high noise levels

DIN 18041 – Group B

Usage type	for room heights $h \leq 2,5$ m m^2/m^3	for room heights $h > 2,5$ m m^2/m^3
B1	No requirement	No requirement
B2	$A/V \geq 0{,}15$	$A/V \geq \left[4{,}80 + 4{,}69 \lg\left(h/1\,\mathrm{m}\right)\right]^{-1}$ (7)
B3	$A/V \geq 0{,}20$	$A/V \geq \left[3{,}13 + 4{,}69 \lg\left(h/1\,\mathrm{m}\right)\right]^{-1}$ (8)
B4	$A/V \geq 0{,}25$	$A/V \geq \left[2{,}13 + 4{,}69 \lg\left(h/1\,\mathrm{m}\right)\right]^{-1}$ (9)
B5	$A/V \geq 0{,}30$	$A/V \geq \left[1{,}47 + 4{,}69 \lg\left(h/1\,\mathrm{m}\right)\right]^{-1}$ (10)

Where

A is the equivalent sound absorption area of a room in square metres

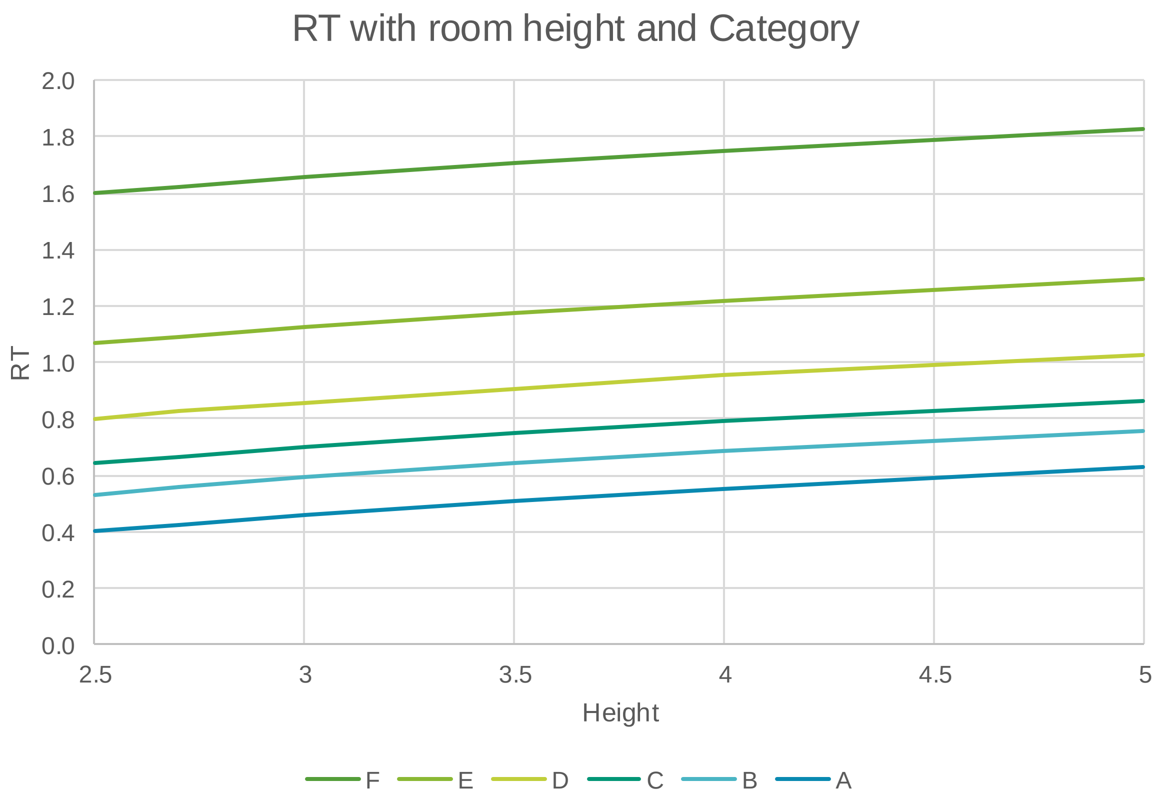
V is the room volume in cubic metres

h is the clear room height in metres

Control of reverberant sound proposals

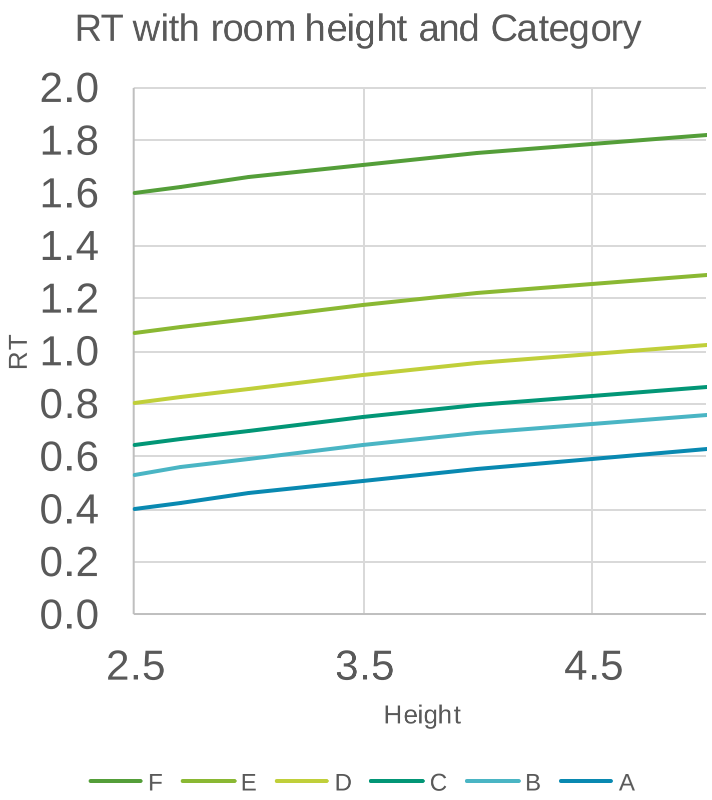
- Categories from A to F
- Minimum values for A/V
- Octave bands from 250 Hz to 2000 Hz
- Normal furnishings intrinsic to the room types included

Cat.	h ≤ 2.5 m **Min. A/V (m²/m³)**	h > 2.5 m **Min. A/V (m²/m³)**
A	0.40	1 / (0.634 + 4.69 lg (h))
B	0.30	1 / (1.47 + 4.69 lg (h))
C	0.25	1 / (2.13 + 4.69 lg (h))
D	0.20	1 / (3.13 + 4.69 lg (h))
E	0.15	1 / (4.80 + 4.69 lg (h))
F	0.10	1 / (8.13 + 4.69 lg (h))



Annex on absorption - education

Room / space type	Category					
	A	B	C	D	E	F
Education						
Cellular primary school classrooms	■	■	■			
Cellular secondary school classrooms	■	■	■	■		
Universally-designed classrooms	■	■				
Open-plan teaching	■	■				
Lecture theatres and auditoriums*	-	-	-	-	-	-
Music classrooms*	-	-	-	-	-	-
Music practice rooms	■	■	■	■		
Libraries and media centres	■	■	■			
Dining areas and canteens	■	■	■			
Changing rooms			■	■	■	
Computer labs	■	■	■			
Art and craft rooms	■	■	■			
Staff rooms	■	■	■			
Corridors – without activities			■	■	■	
Corridors – with activities	■	■	■			
Offices		■	■	■		
Meeting and conference rooms		■	■	■		
Stairwells (without activities)			■	■	■	
Stairwells (with activities)	■	■	■			



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Annex on absorption - healthcare

Healthcare						
Consultation and examination rooms		■	■	■		
Treatment and procedure rooms		■	■	■		
Operating theatres		■	■	■		
Intensive care units		■	■	■		
Recovery areas		■	■	■		
Therapy rooms	■	■	■			
Waiting areas			■	■	■	
Dining areas and canteens	■	■	■			
Laboratories		■	■	■		
Pharmacies		■	■	■		
Staff break rooms	■	■	■			
Meeting and conference rooms		■	■	■		
Chapels and prayer rooms		■	■	■		
Corridors (for circulation purposes only)			■	■	■	
Stairwells			■	■	■	

Annex on absorption - offices

Office Buildings						
Call centres						
Multi-functional open plan offices*	-	-	-	-	-	-
Meeting and conference rooms						
Video conferencing rooms						
Training and seminar rooms						
Dining areas and canteens						
Boardrooms						
Reception areas						
Waiting areas						
Copy and print rooms						
Corridors						
Stairwells in general use (rather than escape purposes)						
Escape stairs						
Car parks						

Annex on absorption – hospitality & retail

Hospitality and Retail						
Cafe						
Restaurant						
Lounges and waiting areas						
Banquet and event spaces						
Fitness centres and gyms						
Spas and wellness areas						
Meeting and conference rooms						
Retail sales floors						
Commercial kitchens						
Corridors						
Stairwells						
Car parks						

Annex on absorption – transport, industrial

Transportation Hubs and Facilities						
Ticket booking and service counters	■	■	■			
Dining areas and food courts	■	■	■			
Prayer and meditation rooms		■	■	■		
Security screening areas		■	■	■		
Administrative offices		■	■	■		
Meeting and conference rooms		■	■	■		
Circulation zones		■	■	■		
Stairwells and escalators		■	■	■		
Industrial and Manufacturing Facilities						
Quality control and testing labs		■	■	■		
Research and development labs		■	■	■		
Packaging and shipping areas			■	■	■	
Administrative offices		■	■	■		
Employee break rooms and cafeterias	■	■	■			
First aid and medical rooms		■	■	■		
Circulation, stairwells			■	■	■	
Storage areas and warehouses						■
Loading bays						■
Canteen	■	■	■			

Annex on absorption - sports

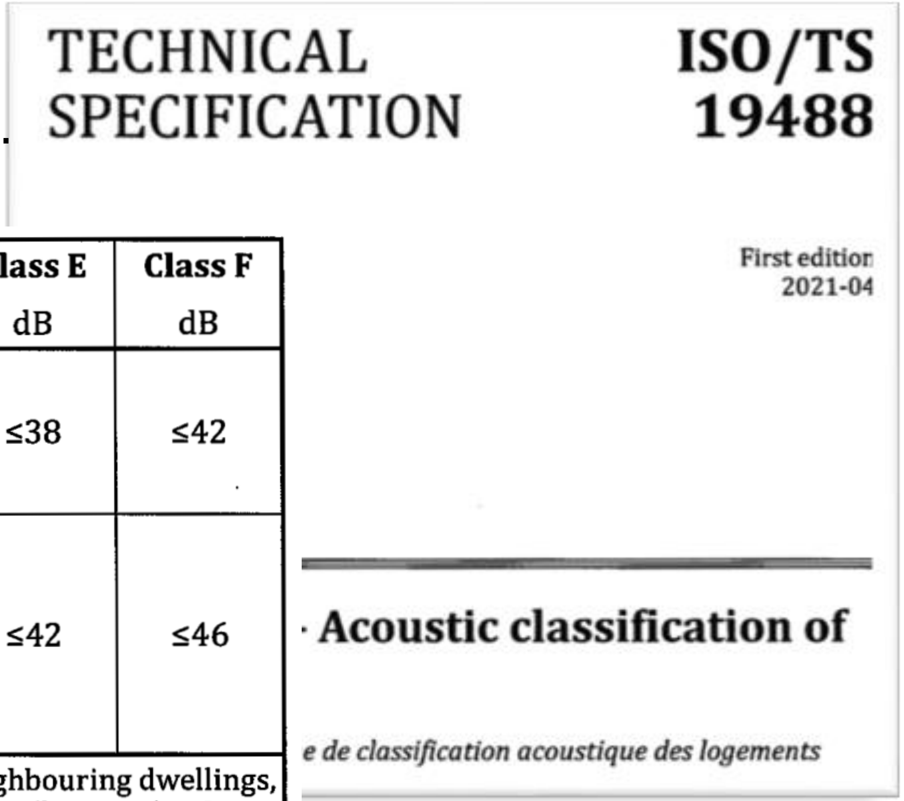
Sports and Recreation Facilities						
Indoor sports halls and courts			■	■	■	
Dance / other class studios			■	■	■	
Swimming pools			■	■	■	
Fitness centres and gyms			■	■	■	
Multipurpose rooms		■	■	■		
Spectator seating areas			■	■	■	
Locker rooms and changing areas			■	■	■	
Bowling alleys			■	■	■	
Billiards and gaming rooms			■	■	■	
Arcades		■	■	■		
Staff offices and break rooms	■	■	■			
Corridors			■	■	■	
Stairwells			■	■	■	
Cafe	■	■	■			

Annex on absorption – cultural & religious

Cultural and Religious Facilities						
Theatres, auditoria *	-	-	-	-	-	-
Cinemas*	-	-	-	-	-	-
Museums and galleries						
Libraries and media centres						
Places of worship (main congregational areas)*	-	-	-	-	-	-
Exhibition halls						
Rehearsal rooms						
Classrooms and workshops						
Meeting and conference rooms						
Administrative offices						
Places of worship (secondary spaces)						
Lobby, foyer						
Corridors and other circulation areas						
Stairwells						
Cafe						

8 – Sound from building services

- Domestic / Non-domestic buildings
- BS ISO/TS 19488 contains guideline values for residential Classes.
- It is suggested that new build dwellings target Class C


TECHNICAL SPECIFICATION

ISO/TS 19488

First edition 2021-04

· Acoustic classification of

e de classification acoustique des logements

	Type of space and sources[ab]	Quantity	Class A dB	Class B dB	Class C dB	Class D dB	Class E dB	Class F dB
1	In habitable rooms in dwellings from outdoor and indoor service equipment producing continuous sound	$L_{A,eq,nT}$	≤22	≤26	≤30	≤34	≤38	≤42
2	In habitable rooms in dwellings from outdoor and indoor service equipment producing intermittent or irregular sound, from neighbouring spaces	$L_{AF,max,nT}$[c]	≤26	≤30	≤34	≤38	≤42	≤46

[a] Requirements relate to sounds that occur more than occasionally due to service equipment in neighbouring dwellings, equipment serving the whole building and service equipment within the dwelling for normal ventilation/heating/cooling.

[b] Sound with tonal components can be perceived more annoying and be subject to national regulations.

[c] $L_{AS,max,nT}$ may also be used, provided that 4 dB stricter limits (lower sound levels) are fulfilled, i.e. the same as $L_{Aeq,nT}$.

Thank you for listening
Grateful to hear your questions

https://forms.gle/v9M1Vbps9VjP8R2y5

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10 - Uncertainty.

Measurements:

A list of possible sources of uncertainty is provided and the approach taken is to take steps to reduce uncertainty to as low a level as possible.

Although the uncertainty due to the instrumentation system can be quantified, this is unlikely to be practicable for some of the other measurement uncertainties.

Guidance on the quantification of uncertainty can be found in “A Good Practice Guide on the Sources and Magnitude of Uncertainty Arising in the Practical Measurement of Environmental Noise” by Craven and Kerry (2007).

10 - Uncertainty.

Calculations:

As for measurements a list of possible sources of uncertainty is provided along with the following guidance:

Where the sound power level is used for calculating sound pressure levels, it should be representative of the source and the conditions under which the source is expected to operate.

Where possible, use recognized standards to establish the sound power level and the uncertainty (e.g. BS EN ISO 3740 and BS EN ISO 3747).

Use a validated method of calculating sound levels, e.g. ISO 9613-2 or similar.

For simple cases, e.g. where the level of variability in sound propagation resulting from changes in meteorological conditions is likely to be small, simple calculation methods might be sufficient.

11 - Sustainability

- In 1987, the United Nations Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”

- Sustainability is a vast and wide subject. Guidance on sustainability in acoustics can be found at the web site of the Association of Noise Consultants:

- www.association-of-noise-consultants.co.uk/resources/sustainability/

- The guidance considers how acoustics should contribute to a sustainable future, and focuses on how acoustic consultancies can become sustainable businesses, so that the work they do can be achieved as part of a sustainable system.

How to comment.

- Go to - https://standardsdevelopment.bsigroup.com/
- Register then log in.
- The draft for public comment will be in the drafts section.
- Please do not write long rants about how dare they change x/y/z etc as that is unhelpful.
- Make your comments as clear as possible.
- It is essential that you propose alternatives as they will be considered by the drafting panel when assessing the comments.
- Whilst personal opinion and/or experience is valuable it will help the review drafting panel if you can cite evidence for your proposed change/s such as conference papers and/or research reports etc that support your comment and proposed changes.
- Do comment as the drafting panel are not the sole source of good ideas. The aim is to make the revised standard the best it can be given the current knowledge base.

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