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SOUND INSULATION BETWEEN RESTAURANTS AND RESIDENTIAL DWELLINGS

Yuliya Smyrnova, Dijon Wall

Peak Acoustics, Ltd. ; Fernbank House, Springwood Way, Macclesfield, SK10 2XA, UK
e-mail: yuliya@acousticsurveys.co.uk; y.smyrnova@gmail.com

Evert de Ruiter

Peutz consulting engineers, P.O. Box 696, 2700 AR Zoetermeer, The Netherlands
e-mail: e.deRuiter@peutz.nl; ephjdeRuiter@gmail.com

Noise break in from restaurants and bars into residential dwellings located next or above is a common issue that acoustic consultants encounter at noise assessment surveys. Sound from a restaurant or bar can enter the residential space though ceiling-floor/wall partition and/or the external elevation. In contrast to Dutch rules, no strict regulation exists in the UK on how to predict and assess the noise levels break in. BS8233:2014 only contains guidelines that stipulate criteria for sound insulation between internal partitions that can be adapted depending on the noise activity, noise sensitivity and privacy requirements.
This paper investigates possible solutions and presents simple rules that can be useful for predicting noise break in levels through both internal partitions and external elevations. It also suggests practical criteria for noise break in assessments. Examples are given for a number of case studies for a range of restaurants and bars; these are based on the British regulations, and compared to a judgment according to the Dutch requirements.

1. Introduction

Noise break-out from restaurants and bars into residential dwellings is a common issue that acoustic consultants encounter at noise assessment surveys. Direct neighbours, next to or above a restaurant can experience nuisance from such premises; this goes for dwellings in the direct vicinity as well [1]. There is no common European guideline on how to assess noise break-outs.

Assessment of noise in residential areas and in dwellings is addressed in ISO 1996 [2]. It is the base of many other regulations. In the UK the most suitable guidelines are stipulated in BS8233:2014 [3] that provide criteria on sound insulation between internal partitions that can be adapted depending on the noise activity, noise sensitivity and privacy requirements. No penalty due to character of noise is taken into account in BS8233 recommendations.

In The Netherlands, noise levels inside residential dwellings are regulated by a comprehensive decree called “Activiteitenbesluit milieubeheer” (Decree environmental control of activities; October 2007). A penalty of 5dB each is added for tonality and impulsivity of noise entering the room. It is usually assumed that music contains both that results in a penalty of 10dB.

This paper investigates possible solutions and presents simple rules that can be useful for predicting noise break-in levels, through both internal partitions. It also suggests practical criteria for noise break-out assessments.

Examples are given for a number of case studies from a range of restaurants and bars; these are based on British regulations, and compared with judgments according to Dutch requirements.

2. British Regulations

The purpose of BS8233:2014 *"Sound insulation and noise reduction for buildings – code of practice"* is the provision of recommendations for the control of noise in and around buildings. It suggests appropriate criteria and limits for different situations, which are primarily intended to guide the design of new or refurbished buildings undergoing a change of use rather than to assess the effect of changes in external noise climate.

Table 1. BS8233: Guideline noise levels within living areas.

Criterion	Typical Situations	Design Range $L_{Aeq,T}$ (dB)	
		Good	Reasonable
Reasonable resting/sleeping conditions	Living rooms	30	40
	Bedrooms	30	35

No additional requirements are set with regard to the temporal or spectral content of sound such as impulsivity or tonality.

BS8233:2014 also states that in addition to controlling exterior noise and internal services noise, sound from adjacent spaces can affect the intended use, depending on the noise activity, noise sensitivity and privacy requirement. It also suggests that sound insulation requirements of separating partitions between spaces should be established based on noise activity, sensitivity and privacy requirements for each room and space. BS8233:2014 gives an example of sound insulation matrix that can be adapted according to the specific building use.

Table 2. Example of on-site sound insulation matrix (dB $D_{nT,w}$), BS8233:2014.

	Activity noise of source room	Noise sensitivity of receiving rooms		
Privacy requirements		Low sensitivity, dB	Medium sensitivity, dB	Sensitive, dB
Confidential	Very high	47	52	57
	High	47	47	52
	Typical	47	47	47
	Low	47	42	47
Moderate	Very high	47	52	57
	High	37	42	47
	Typical	37	37	42
	Low	No rating	No rating	37
Not private	Very high	47	52	57
	High	37	42	47
	Typical	No rating	37	42
	Low	No rating	No rating	37

Restaurants can be assumed as spaces of **Very High/High** activity while living rooms and bedrooms can be assumed as **Sensitive** spaces with a desirable value of 57 dB of $D_{nT,w}$.

3. Protection of neighbours from restaurant noise: the Dutch way

In the case that the restaurant is very quiet (sound level L_{eq} < 60 - 70dB(A)) no special demands are in force. In other cases, it is the representative immission sound level that is to be guarded. Depending on the time of day, different limits are set in rooms within adjacent dwellings and in front of façades of nearby dwellings. The values are given in Table 3.

Table 3. Noise limits L_{eq} in dB(A).

	Day (07:00-19:00)	Evening (19:00-23:00)	Night (23:00-07:00)
In rooms	35	30	25
In front of façades	50	45	40

The values of measured or calculated sound levels are increased by a “penalty”; 10 dB if the noise has a musical character.

In different stages of design, completion and use of the building construction, the characteristic values for **E**mission (source level), **T**ransmission (sound reduction) and **I**mmission play different roles. This is shown in Table 4. In the design stage of a new building, or a refurbishment of an existing one, the requirements for the sound insulation of constructions have to be derived from an assumption of the sound levels in the source room; the maximum immission level is in Table 3. After completion of the construction works, measurements of the resulting sound reduction will be taken. From the measured sound reduction values and the noise limits (Table 3 again) the maximum allowable sound pressure level in the source room (restaurant) is deducted. In all cases, the expected sound spectrum in the source room is taken into account. Consistency of the restaurant with the rules will be assessed by the authorities, based on the actual sound pressure level in the restaurant. In many cases an electronic noise limiter is installed -voluntarily, or demanded by the authorities- to avoid music levels exceeding the allowable value.

Table 4. Emission, Transmission and Immission in different stages.

	Design stage	Completion assessment	Normal use
(E) source level	*1. assumption*	*3. maximum allowable*	*Measured = criterion*
(T) sound reduction	*3. requirement*	*1. measured*	*(established)*
(I) immission level	*2. fixed (limit)*	*2. fixed (limit)*	
	Calculations	**Measurements**	**Measurements**

The normalised sound reduction index D_{nT} between a restaurant and a space next or above depends on the sound insulation R of the separating floor and the properties of the receiving room in the dwelling, and is calculated from the simple formula:

$$R = D + 10\log(S/A) = D_{nT} + 10\log(6*T_0/h). \quad (1)$$

Where S is area room, A is absorption area, h is height of the immission (receiving) room and T_0 is reference reverberation time (in the immission room).

Next the frequency weighting. We have R_w on the one hand, and A-weighted values for certain spectra on the other. In The Netherlands, several spectra for different kinds of music are used.

Especially some recent kinds like house-music contain very high bass levels. Here those extreme types of "music" are not considered, but a moderate spectrum of popular music was used.

4. Case studies

Examples are given for a number of case studies for a range of existent or proposed restaurants and bars; these are based on the British regulations, and compared to a judgment according to the strict Dutch requirements. All sites are located in the UK.

Case 1: The site is located in city centre of Lincoln, where the ground floor space is occupied by an existing Italian restaurant and the first floor is dedicated to a residential flat. The sound environment is rather busy due to nearby shopping area, pedestrians and passing by/parking vehicles.

The existing floor partition has been identified as comprised from (top to bottom) 20.0mm, floor boards, solid timber joist at 600mm centres and 50.8mm gypsum plaster/lath. Airborne sound insulation of the existing ceiling-floor partition has been predicted using Insul® as **46 dB** $\boldsymbol{D_{nT,w}}$.

Case 2: The site is a ground floor fish & chip restaurant serving food to be consumed on site, but mainly as a take-away. It is located on the outskirts of Southampton within a relatively quiet area. The first floor is occupied by residential flats. No loud music is intended to be played inside the restaurant.

The ceiling-floor partition has been assumed to be built from: a timber or plywood floor boarding (18mm thickness), timber joists (100mm), concrete panel (152mm), lath and plaster (20mm), and suspended ceiling boards (10mm). Airborne sound insulation has been predicted as **65 dB** $\boldsymbol{D_{nT,w}}$.

Case 3: The site is located in the city centre of London. It is a multi-storey building with the first floor dedicated to a restaurant with a bar and all upper floors are residential apartments. It is likely that the restaurant will be operating after 23:00 and loud music will be played.

The original ceiling-floor partition consists of 14mm wooden flooring, 1-2mm underlay, chipboard based acoustic deck overlay (32mm), 375mm reinforced concrete slab and 12.5mm plasterboard. These result in an airborne sound insulation value of **66 dB** $\boldsymbol{D_{nT,w}}$.

4.1 Noise break out assessment

Recommendations on improvement of sound insulations between restaurant and residential dwellings above have been made following criteria set in BS8233. Specifications for the proposed amendments and the resulting $D_{nT,w}$ of the overall partitions values are shown in Table 5.

Table 5. Additional internal partition specifications and $D_{nT,w}$ of the overall partitions.

Case study	Additional Internal partition specs.	$D_{nT,w}$, dB
1	Change in the floor: adding 18.0mm cement particle board, 20.0mm chip board and 50.0mm thick fibreglass infill	58
2	Change in the ceiling: adding 12.5 mm Gyproc SoundBloc underneath of the existing lath plaster in the suspending ceiling cavity; adding 100mm fibreglass.	71
3	Change in the ceiling: adding an additional ceiling of two plasterboards of 12.5mm each with 100mm fibreglass between joist	73

Changes in the existing floor partitions are compliant with criteria on airborne sound insulation set in BS8233 between the spaces of **Very High/High** activity and **Sensitive** receiving rooms.

Resulting admissible levels, calculated following the procedure within Dutch regulations, are shown in Table 6.

Table 6. Admissible levels in the case studies according to Dutch regulations.

Case study	Sound reduction, D_{nT} [dB(A)]	Admissible source level [dB(A)]
1	50	70
2	54	73
3	69	88

The third case allows music sound levels up to 88 dB(A); for a restaurant this means little to no restriction. In the other cases, admissible music sound levels of 70 - 73 dB(A) could be considered as very quiet background music. Other restaurant sounds consist mainly of conversation. The admissible level for this kind of sound is 80 - 83 dB(A), as there is no penalty. This value will usually not be exceeded; moreover, for pleasant dining, sound levels should certainly be much lower than 80 dB(A) [4].

5. Discussion

There is inconsistency in guidelines for sound insulation between restaurants/bars and residential spaces, deemed to satisfy the UK and Dutch regulations. Criteria based just on sound insulation values, without consideration of particular characteristic of sound immissions (the UK) may not necessarily guarantee satisfactory internal noise levels in the adjacent spaces. Dutch regulations provide higher restrictions and also consider the spectral content of different kinds of music that could be emitted from a restaurant or bar, such as impulsivity and tonality. These regulations could be potentially improved by consideration of other immissons characteristics, in a way similar to those introduced in BS4142:2014 [5].

Based on Joint Nordic Method BS4142:2014 describes a penalty between 0 dB and +6 dB for **tonality**. Subjectively, sound can be subjected to a penalty of 2 dB for a tone which is just perceptible at the noise receptor, 4 dB where it is clearly perceptible, and 6 dB where it is highly perceptible. A correction of up to +9 dB can be applied for sound due to **impulsivity**, considering both the rapidity of the change in sound level and the overall change in sound level. Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied. Further penalty of 3dB can be applied due to **intermittency** of the sound source.

Although sounds generated in restaurants and bars may lack some of the above temporal features it is worth considering at least some of them in developing more strict regulations for noise –break out especially in the UK but also in continental Europe. Other possible assessment criteria may include particular frequencies bands such as 125Hz and 250Hz (or even 31.5Hz for house music) octaves in which emitted noise levels can reach up to 110dB and 115dB, respectively. Higher criteria for inaudibility in those frequencies would be required due to a more flat shape of the A-weighting curve for higher sound pressure levels.

Repetitive, transient, low-frequency features (bass beats) within music have been described as having additional impact on human receptors [1], and a method is suggested by Salford University's working group to assess such impact. A deduction of L_{90} from L_{10} values in 63Hz and 125Hz frequency bands should form part of an overall noise impact assessment. Entertainment noise featuring bass beats (e.g. techno, drum 'n' bass, house music) played within restaurants/bars could

therefore cause additional difficulty and variability with regard to the assessment of noise impact from entertainment sources.

Robust regulations would make it possible to keep noise break-out (and therefore noise nuisance) under control and also would simplify matters for local authorities when they oblige applicants to provide noise assessment details.

6. Conclusions

Noise annoyance and nuisance caused by noise break-out from a restaurant or bar neighbouring a residential space has become a widespread problem in many European countries, including the UK and The Netherlands.

In the UK there is no strict regulation on noise-break out levels though ceiling-floor/wall partition or external elevation apart of recommendation on $D_{nt,\,w}$. Dutch legislation provides stricter regulations that also take the spectrum of the emitted music into account.

Examples are given for a number of case studies in which sound reduction index would satisfy recommendations provided in the UK BS8233:2014 standard. Calculations based on the Dutch regulations have shown that in most of the cases the admissible noise levels would be about 70-73 dB(A), which is the category of very quiet music.

Suggestions for more strict and rigorous regulations that should include both spectral and temporal characteristics of the emitted sounds have been made.

REFERENCES

1. Davies, W.J., Hepworth, P., Moorhouse, A. & Oldfield, R.: DEFRA/Salford University report "*Noise from Pubs and Clubs, Phase* I", (2005).
2. ISO 1996 *"Acoustics - Description and measurement of environmental noise"*, (1996).
3. BS8233:2014 – *Guidance on sound insulation and noise reduction for buildings.* British Standards Institute, (2014).
4. Ruiter, Evert de; Smyrnova, Yuliya; Brown, Tom; *"Feedback from the food court"* ICSV22, (2015).
5. BS4142:2014 – *Method for Rating and Assessing Industrial and Commercial Sound. British Standards Institute*, (2014).