Facade sound insulation comfort criteria in European classification schemes for dwellings

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FACADE SOUND INSULATION COMFORT CRITERIA IN EUROPEAN CLASSIFICATION SCHEMES FOR DWELLINGS

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ABSTRACT

Acoustic classification schemes for dwellings exist in 9 countries in Europe. The schemes specify class criteria concerning several acoustic aspects, the main criteria being about airborne and impact sound insulation between dwellings, airborne sound insulation of facades and noise from building services and equipment. The different classes in the classification schemes are intended to reflect different levels of acoustical comfort.

There are significant discrepancies between the European schemes, among these descriptors, number of quality classes, intervals between classes, levels of classes and the status of the classification schemes in relation to the legal requirements. In some countries the building code and the classification standard are incoherent. In other countries they are strongly "integrated", implying that the building code refers to a specific class in the classification standard rather than describing the requirements.

The paper describes the facade sound insulation descriptors applied in the European schemes. The Nordic schemes specify max indoor equivalent A-weighted levels, other countries specify the sound insulation as a function of the outdoor level, applying ISO 717 descriptors. None of the schemes apply directly the harmonized environmental noise indicators L_{den} and L_{night} defined in Environmental Noise Directive (2002) for description of annoyance and sleep disturbance, respectively, or psychoacoustic descriptors.

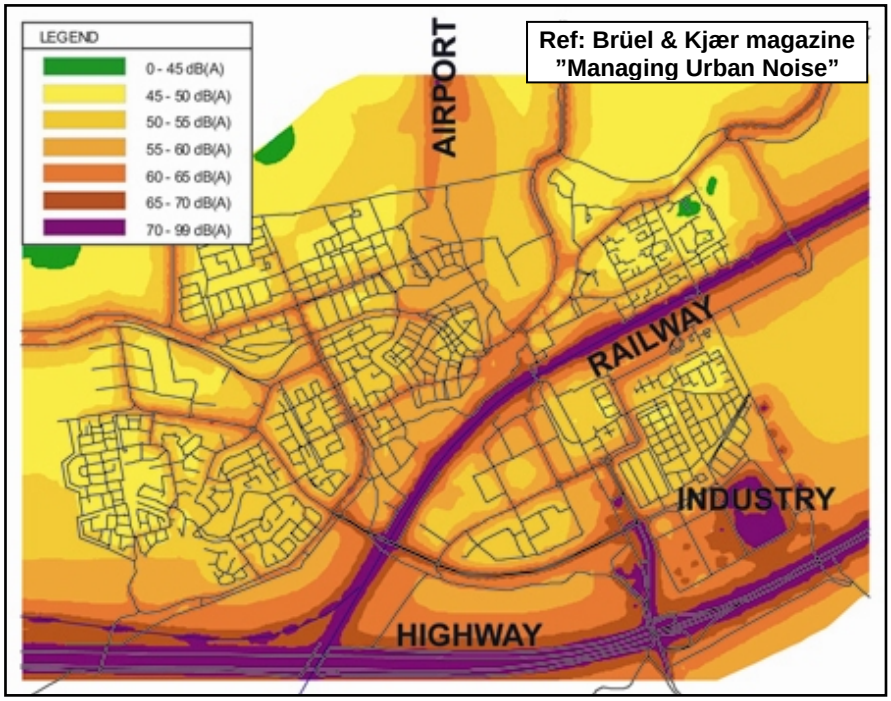
1 INTRODUCTION

While legal requirements for sound insulation between dwellings have existed more than 50 years in several countries in Europe, facade sound insulation requirements appeared a few decades later and were often local instead of national. However, fulfilment of legal requirements does not ensure satisfactory conditions, and for this reason classification schemes have gradually been introduced in nine European countries to meet the need to specify higher levels of acoustical comfort than prescribed by the legal requirements. This paper focuses on facade sound insulation. Sound insulation between dwellings is dealt with in [1].

Independently from the introduction of classification schemes, there is a focus on creating improved acoustic environments in Europe, see the Environmental Noise Directive (END) [2] and the related strategy paper [3]. The aim of current noise policy is to reduce the noise exposure of people in order to avoid adverse effects on health and quality of life, including effects like sleep disturbance, stress and negative effect on learning capabilities of children.

2 THE NEED FOR SOUND INSULATING FACADES

For EU (excluding the new member states) it has been estimated, cf [3], that about 80 million people are exposed to noise levels considered unacceptable, because they lead to sleep disturbance and/or other adverse health effects. Further 170 million people are estimated to live in areas where noise causes serious annoyance. Transportation is the main contributor to environmental noise pollution. The END [2] defines three key elements for future noise policy that constitute a standard approach to the management of environmental noise, see Fig. 1, and the related technical principles for reduction of noise emission and exposure are clearly ranked. Several publications are found at the EU homepage, see e.g. [3], [4], [5], [6], [7].



The END approach:
- Strategic noise mapping (2007ff)
- Informing and consulting the public (2005ff)
- Action plans (2008ff)

Ranked technical principles:
- To avoid and reduce noise at its source
- To reduce noise in its propagation
- To reduce noise at the receiver, including facade sound insulation

Fig. 1. Example of mapping of outdoor noise from road traffic, railways, airports and industry.

3 FACADE SOUND INSULATION DESCRIPTORS AND CLASS CRITERIA

An overview of concepts for evaluation of airborne and impact sound insulation is found in [8] and comments on suitability are given. In [1] are found the legal requirements in 24 countries for sound insulation between dwellings, including information about concepts, about classification schemes and the related main criteria for sound insulation between dwellings. In Table 1 is found an updated overview of European sound classification schemes.

Table 1: European schemes for sound classification of dwellings.

European schemes for sound classification of dwellings March 2006				
Country	**Class denotations**	**Year of implementation**	**Reference**	
Denmark (DK)	A / B / C / D	2001	DS 490 (2001)	[9]
Finland (FIN)	A / B / C / D	2004	SFS 5907 (2004)	[10]
Iceland (IS)	A / B / C / D	2003	IST 45 (2003)	[11]
Norway (N)	A / B / C / D	1997/2005	NS 8175 (2005)	[12]
Sweden (S)	A / B / C / D	1996/1998/2004	SS 25267 (2004)	[13]
France (F)	QL / QLAC *	1993/1995/2000	Méthode Qualitel (2000)	[14]
Germany (D)	I / II / III	1994	VDI 4100 (1994)	[15]
Lithuania (LT)	A / B / C / D / E	2004	STR 2.01.07 (2003)	[16]
Netherlands (NL)	1 / 2 / 3 / 4 / 5	1999	NEN 1070 (1999)	[17]
***The indicated class denotations are applied for sound insulation between dwellings, not for facade sound insulation, see note in Table 3.				

The facade sound insulation concepts according to EN ISO 717-1:1996 [18] are:
Basic single-number quantities: $\boldsymbol{R'_w}$, $\boldsymbol{D_{n,w}}$, $\boldsymbol{D_{nT,w}}$
which may to be combined with one of the following spectrum adaptation terms*:

None, C, $\boldsymbol{C_{50\text{-}3150}}$, $\boldsymbol{C_{100\text{-}5000}}$, $\boldsymbol{C_{50\text{-}5000}}$, $\boldsymbol{C_{tr}}$, $\boldsymbol{C_{tr,50\text{-}3150}}$, $\boldsymbol{C_{tr,100\text{-}5000}}$, $\boldsymbol{C_{tr,50\text{-}5000}}$

i.e. in total: ***3 x 9 = 27 concepts!***

* Table 2 describes the intended applications of spectrum adaptation terms related to facade sound insulation

Table 2: Relevant sound insulation spectrum adaptation terms for different types of external noise sources. Ref.: Table A.1 from ISO 717-1:1996. The spectra 1 and 2 are defined in ISO 717-1.

C (Spectrum 1: A-weighted pink noise)	$\mathbf{C_{tr}}$ (Spectrum 2: A-weighted urban traffic noise)
Railway traffic at medium and high speed Highway road traffic > 80 km/h Jet aircraft short distance Factories emitting mainly medium and high frequency noise	Urban road traffic Railway traffic at low speeds Aircraft propeller driven Jet aircraft large distance Factories emitting mainly low and medium frequency noise

In Table 3 are found the facade sound insulation criteria for the nine schemes existing in Europe. Some findings and comments:

- Indoor noise level limits applied in DK, FIN, IS, N, S
- Minimum facade sound insulation as a function of outdoor noise level applied in D, F, LT, NL
- Max levels (combined with the indoor level limits) in IS, N, S
- Significant differences between concepts and details of criteria, e.g. night indicators, see [19]
- No psychoacoustic descriptors applied, for discussion see [20]

Table 3: European schemes for sound classification of dwellings. – Facade sound insulation criteria.

European schemes for sound classification of dwellings
Main criteria for airborne sound insulation of facades in living rooms

March 2006

Country (6) with indication of reference		**Concept** (indoor level or sound insulation)	Required performance for quality levels (1), [dB] Class A F: N/A D: Class III NL: Class 1	Class B F: N/A D: Class II NL: Class 2	Class C F: N/A D: Class I NL: Class 3	Class D F: N/A D: N/A NL: Class 4	Class E F: N/A D: N/A NL: Class 5	**Comments**
DK	[9]	$L_{Aeq,24h}$ (indoor)	≤ 20	≤ 25	≤ 30	≤ 35	N/A	See note (2)
FIN	[10]	$L_{Aeq,\ 7\text{-}22}$ (indoor)	≤ 25	≤ 30	≤ 35	≤ 35	N/A	See note (2)
		$L_{Aeq,\ 22\text{-}7}$ (indoor)	≤ 20	≤ 25	≤ 30	≤ 30	N/A	
IS	[11]	$L_{pA,eq,\ 24\ h}$ (indoor)	≤ 20	≤ 25	≤ 30	≤ 35	N/A	See note (2)
		$L_{pA,max,\ 22\text{-}06}$ (indoor)	≤ 35	≤ 40	≤ 45	None	N/A	
N	[12]	$L_{pA,eq,24h}$ (indoor)	≤ 20	≤ 25	≤ 30	≤ 35	N/A	See note (2)
		$L_{pA,max,\ 23\text{-}07}$ (indoor)	≤ 35	≤ 40	≤ 45	≤ 50	N/A	
S	[13]	$L_{pAeq,24h}$ (indoor)	≤ 22	≤ 26	≤ 30	≤ 34	N/A	See note (2)
		$L_{pAFmax,\ 22\text{-}06}$ (indoor)	≤ 37	≤ 41	≤ 45	≤ 49	N/A	
F	[14]	$D_{nT,w} + C_{tr}$						See note (5)
D	[15]	$R'_{res,\ w}$	≥ DIN 4109 + 5 dB	≥ DIN 4109	≥ DIN 4109	N/A	N/A	DIN 4109 defines the legal requirem.
LT	[16]	$D_{2m,nT,w}$	≥ 40 (32)	≥ 35 (32)	≥ 30	≥ 25 (28)	≥ 23 (28)	See notes (2), (3)
NL	[17]	$D_{2m,nT,w}$+ C * $D_{2m,nT,w} + C_{tr}$ **	≥ B_g – 27 Min/max 28/32	≥ B_g – 27 Min 28	≥ B_g – 32 Min 23	≥ B_g – 37 Min 18	≥ B_g – 42 Min 18	See note (4) * Railways ** All other sources *** Information only
		Goal*** "L_{den}" (indoor)	≤ 30***	≤ 30***	≤ 35***	≤ 40***	≤ 45***	

Notes

(1) The full sets of criteria are found in the references. Descriptors are defined in the respective references. The spectrum adaptation terms C and C_{tr} are defined in EN ISO 717-1.

(2) The weaker class D and the Lithuanian Class E are intended for specification of requirements for renovation of older housing. Concerning legal minimum requirements the Finnish, Norwegian, Swedish and Lithuanian building codes refer to class C. Class C in the Danish standard [6] corresponds to the present legal requirements, but there is no link between the building code and the standard.

(3) The numbers are the criteria for the outdoor noise class equaling C, the numbers in brackets are criteria for the outdoor noise class being the same as the class for the facade. Outdoor noise classes are A / B / C / D / E with upper limits L_{den} 45 / 50 / 55 / 60 / 65 dB. As an alternative to $D_{2m,nT,w}$, the descriptor $D_{2m,nT,w} + C_{tr}$ may be applied and the criteria decreased by 7 dB.

(4) In NL new housing should fulfil at least class 3, preferably 2. The classes 5 and 4 are intended for renovation purposes. For class 1 the requirement is limited: Class 1 can not be assigned in a very noisy environment. Class 3 corresponds approximately to the legal requirements. $B_g \approx L_{den}$ as defined in END(2002), with a minimum value of 55 dB(A), if no specific sources are present. If $B_g > 55$ dB(A), the requirement refers to ventilated facades, if relevant.

(5) While the acoustic part of Méthode Qualitel has two quality levels for sound insulation between dwellings, the lower one equalling the legal requirements in NRA, there is only one set of facade criteria. They are identical to the legal requirements, e.g. dependant on the specific situation and with no additional higher quality level than in NRA.

(6) As an alternative to extensive classification schemes, some countries have defined a simple set of criteria for specification of increased acoustical comfort, for example added in an Annex in the document describing the legal requirements. Such criteria are found in e.g. Austria (ÖNORM B 8115-2:2002) and Switzerland (SIA 181:2006).

References

See references in the end of the paper.

Fig. 2 illustrates further aspects to be considered. Assignment of noise levels to facades of dwellings is discussed in [21] based on GPG [7].

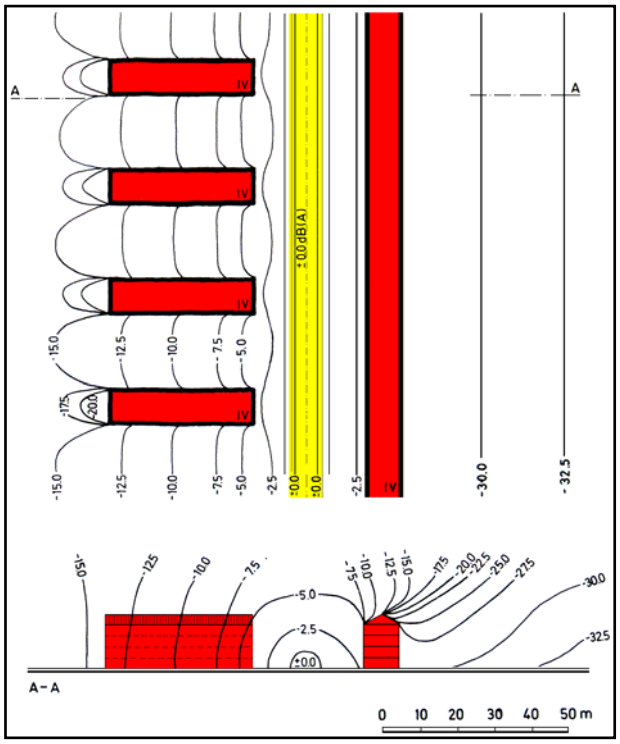


Fig. 2. Example of traffic noise contour lines around buildings close to a road. Ref.: Wiener Lärmbericht 1997

Important discussion points:

- Outdoor noise mapping focus on sources, not necessarily at exposure of relevant facades. Missing link between mapping values and the noise level at the facade? Method?
- Determination of the needed sound insulation of facades based directly on mapping values close to the road? or on the exposure level at the relevant facade? in the actual height?
- There is a tradition to use 5 dB noise mapping intervals and in some countries 5 dB steps of the required sound insulation, leading to non-optimal requirements for facades and facade components, sometimes to the same requirement for up to 10 dB variation of exposure.

4 CONCLUSIONS

Comparison of the nine European schemes shows:

- There are significant differences concerning criteria. Especially night time criteria differ considerably, implying a need for justification or change.
- In four countries (FIN, N, S, LT) the building codes refer to class C as minimum requirements. The higher classes and the schemes in the other 5 countries are voluntary.
- In general, determination of the needed facade sound insulation does not seem to take into account sufficiently the actual noise exposure at different positions at the building leading to non-optimized design.

The following topics are suggested for further investigations and actions:

- Investigate the suitability of the present night time indicators and develop an improved method less uncertain and with documented correlation with sleep disturbance.
- Investigate correlation of criteria with subjective evaluation using psychoacoustic descriptors, e.g. loudness according to ISO 532 [22], and develop new methods, if needed.
- Investigate the variation of noise exposure around a building envelope and propose a way to adjust the “design” accordingly.
- Investigate whether mapping values using the European outdoor noise indicators L_{den} and L_{night} are suitable as a basis for facade sound insulation requirements.
- Harmonization of concepts and criteria related to facade sound insulation is recommended.

This paper is intended to provide input for discussions in EAA TC-RBA WG4: "Sound insulation requirements and sound classification - Harmonization of concepts", [23] aiming at harmonization of concepts for legal requirements and classification criteria in Europe.

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