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Sound insulation of dwellings - Overview of classification schemes in Europe

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The paper presents an overview of the main characteristics of sound classification schemes for dwellings in 8 countries in Europe. While legal sound insulation requirements for dwellings have existed for more than 50 years, schemes describing classes of acoustic quality of dwellings have been introduced during the last decade.
The status of the classification schemes in relation to the legal requirements varies. In some countries the building code and the classification standard are incoherent. In other countries they are strongly "integrated", i.e. the building code refers to a specific class in the classification standard rather than describing the requirements. Consequently, attention is drawn to the fact that the legislative requirements are minimum requirements, and an incentive to voluntarily specify and design for an increased acoustic quality is provided.
There are significant discrepancies between the European classification schemes, among these descriptors, number and levels of quality classes, intervals between classes. In some of the sound classification schemes, an extended frequency range down to 50 Hz is applied, which is of importance for light-weight buildings.
Although the schemes prove useful on a national basis, the diversity in Europe is an obstacle for exchange of information and experience and for further development of design tools, which is especially important to get experience with the low-frequency performance of light-weight buildings. Thus, there is a need to promote harmonisation of concepts and preferably also other characteristics of the schemes.

1. INTRODUCTION

In spite of the facts that a dwelling is probably the biggest investment during most people's life-time, that much time is spent in the dwelling, and that acoustical comfort is very important to the well-being, objective information about the acoustic conditions is rarely available. This is very unsatisfactory to prospective occupants of a dwelling, as acoustic quality is a ‘hidden’ quality, which is not easily evaluated by other means. Fulfilment of legal requirements does not ensure satisfactory conditions. The different classes in sound classification schemes are intended to reflect different levels of acoustical comfort. From surveys on noise from neighbours, see eg [1], [2], [3], [4], [5], it is possible to derive approximate relationships between the acoustic conditions and the expected percentage of people finding the conditions good or satisfactory. As an example the current Swedish requirements on airborne and impact sound insulation can be estimated to give satisfactory conditions for approx. 40%, cf [1].
An overview of legal main requirements in 18 countries in Europe is found in Section 2. The European classification schemes and some comments on the relation to legal requirements are described in Section 3.

2. LEGAL REQUIREMENTS IN EUROPE

The legal main requirements on airborne and impact sound insulation between dwellings in 18 European countries are presented in Figure 1 and 2. In order to facilitate a comparison between countries, all requirements have been converted into equivalent values of R'_w and $L'_{n,w}$. In case of the equivalent value being an interval, the average value has been indicated. A comparison between the 18 different countries reveals significant discrepancies in requirements. For airborne sound insulation requirements, there are 8 concepts + variants and recommendations. The differences in equivalent R'_w are up to 6 dB for multi-storey housing and 11 dB for terraced housing. Concerning impact sound insulation requirements, 5 concepts + variants and recommendations are applied. The variation of equivalent $L'_{n,w}$ is 19 dB for multi-storey housing and 21 dB for terraced housing. The strictest requirements are found in Austria. For more detailed information, se [1]. The most recent version of the standard EN ISO 717 [6] has contributed to the diversity in concepts by allowing many different concepts and by introducing spectrum adaptation terms with different extended frequency ranges, see [7].

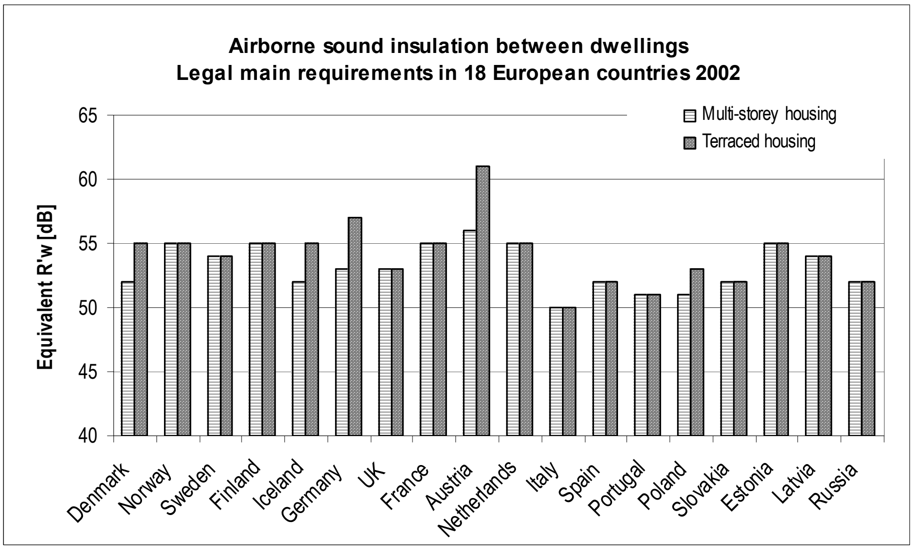

Figure 1. *Overview airborne sound insulation requirements in 18 European countries.*

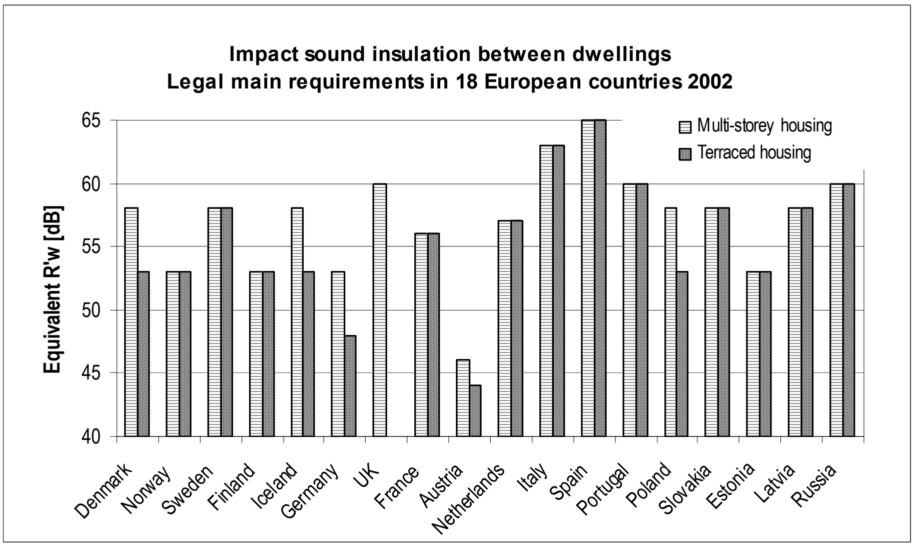

Figure 2. *Overview impact sound insulation requirements in 18 European countries.*

Typically, sound insulation requirements have originally, i.e. more than 50 years ago, been based on the actual performance of traditional building constructions - which have been considered to offer a sufficient level of sound insulation - and since then remained essentially unchanged, although neighbour noise levels and the demand for comfort have increased. There may be several reasons for being reluctant to change of requirements, one of them being the fear for economic consequences, another being the difficulties with update of guidelines without extensive experience. In spite of this, stricter requirements have been implemented or proposed in some countries during the last few years, but it is a very slow process for the above-mentioned reasons. However, sound classification schemes can partly compensate for lack of appropriate legal requirements and at the same time provide different quality levels.

3. SOUND CLASSIFICATION SCHEMES IN EUROPE

An overview of existing and proposed classification schemes is found in Table 1. The main criteria for airborne and impact sound insulation between dwellings are found in Table 2. Criteria for sound insulation internally in dwellings are found in Table 3. The schemes include several other criteria concerning sound insulation and noise levels, see the standards [8], [9], [10], [11], [12], [13], [14], [15], [16]. For lightweight buildings it is important that low-frequency spectrum adaptation terms (down to 50 Hz) according to [6] are included, implying a significantly improved correlation between subjective and objective sound insulation, see [1].

Table 1: *European schemes/proposals for sound classification of dwellings.*

European schemes/proposals for sound classification of dwellings March 2003			
Country	**Class denotations**	**Year of implementation**	**Reference**
Denmark	D / C / B / A	2001	DS 490 (2001)
Norway	D / C / B / A	1997	NS 8175 (1997)
Sweden	D / C / B / A	1996/1998	SS 02 52 67 (1998)
Iceland	D / C / B / A	2003? (still draft)	DP/ INSTA 122 (1997/1998)
Germany - VDI	I / II / III	1994	VDI 4100 (1994)
Germany - E DIN	I / II / III	???? (still draft)	E DIN 4109-10 (February 2002)
France	QL / QLAC	1993/1995/2000	Guide Qualitel (2000)
Netherlands	5 / 4 / 3 / 2 / 1	1999	NEN 1070 (1999)
Estonia	D / C / B / A	2003? (still draft)	Building Code, Inf. Annex (1999)

Concerning sound insulation against traffic noise, the schemes in Norway, DK and Iceland specify max indoor level $L_{A,eq,24h}$ 35 / 30 / 25 / 20 dB for classes D / C / B / A (class C equals legal req.). Sweden has slightly different criteria. The upper class seems to be quite strict and maybe not realistic. The German schemes (and legislation) apply a different approach. The sound insulation of the facade is specified as a function of the outdoor level, and. Class I and II refer both to the same legal requirements, while class III specify +5 dB higher sound insulation. Future criteria for facades should be expressed by the harmonised environmental noise indicators L_{den} and L_{night} for description of annoyance and sleep disturbance, respectively, see [17].

Table 2: *Main criteria in European schemes/proposals for sound classification of dwelllings.*

European schemes/proposals for sound classification of dwellings
Main criteria for airborne and impact sound insulation between dwellings
March 2003

Country with indication of class denotation and reference		**Required performance for classes** (1)		**Comments**
		Airborne sound insulation R'_w or $R'_w+C_{50\text{-}3150}$ [dB]	**Impact sound insulation** $L'_{n,w}$ or $L'_{n,w}+C_{i,50\text{-}2500}$ [dB]	
Denmark D / C / B / A	[6]	≥ 50 / 55 / 58* / 63*	≤ 58 / 53 / 48* / 43*	See note (3)
Norway D / C / B / A	[4]	≥ 50 / **55**(*) / 58(*) / 63(*)	≤ 58 / **53**(*) / 48(*) / 43(*)	See note (3)
Sweden D / C / B / A	[3]	≥ 48 / **52**(*) / 56* / 60*	≤ 62 / **58**(*) / 54* / 50*	See note (3)
Iceland D / C / B / A	[7]	≥ 50 / 55(*) / 58* / 63*	≤ 58 / 53 / 48* / 43*	See note (3)
Germany VDI I / II / III	[2]			See note (2)
Multi-storey housing		≥ **53** / 56 / 59	≤ **53** / 46 / 39	
Terraced housing		≥ **57** / 63 / 68	≤ **48** / 41 / 34	
Germany E DIN I / II / III	[9]			See note (2)
Multi-storey housing		≥ **53** / 56 / 59	≤ **53** / 46 / 39	
Terraced housing		≥ **57** / 63 / 68	≤ **48** / 41 / 34	
France QL / QLAC	[1]	**$D_{nT,w}$ + C** ≥ **53** / 56	≤ 55 / 52	
The Netherlands 5 / 4 / 3 / 2 / 1	[5]	**$D_{nT,w}$ + C** ≥ 42 / 47 / 52 / 57/ 62	**$L'_{nT,w}$ + C_i** ≤ 63 / 58 / 53 / 48 / 43	See note (4)
Estonia D / C / B / A	[8]	≥ 50 / 55(*) / 58* / 63*	≤ 58 / 53 / 48* / 43*	See note (3)

Notes

(1) The full sets of criteria are found in the references.
XX: Legal minimum requirements are indicated with **bold**. More information about the legal requirements is found in the Tables 2.1 and 2.2.
*XX**: Numbers in *Italic* and marked with a "*" include the spectrum adaptation terms $C_{50\text{-}3150}$ or $C_{i,50\text{-}2500}$ as defined in EN ISO 717-1 and 717-2, respectively. For numbers marked with a "(*)" the standard only recommends that $C_{50\text{-}3150}$ and $C_{i,50\text{-}2500}$ are included in the criteria applied.

(2) Horizontal, requirement for vertical is 1 dB higher.

(3) The weaker class D is intended for specification of requirements for renovation of older housing. Concerning legal minimum requirements the Swedish and Norwegian building codes refer to class C in [3] and [4], respectively. Class C in the Danish standard [6] corresponds to the present requirements for terraced housing, but there is no link between the building code and the standard.

(4) New housing should fulfil at least class 3, preferably 2. The classes 5 and 4 are intended for renovation purposes.

References

[1] Guide Qualitel (2000). Note: The first edition was published in 1993.
[2] VDI 4100 (1994).
[3] SS 02 52 67 (1998). Note: The first edition was published in 1996.
[4] NS 8175 (1997).
[5] NEN 1070 (1999).
[6] DS 490 (2001).
[7] Draft proposal INSTA 122 (1997/1998). Work item based on an NKB proposal on acoustic classification of dwellings. Final IST-standard expected in 2003.
[8] Estonian Building Code, Annex 5 - informative (1999). (Draft proposal INSTA 122 1997/1998).
[9] E DIN 4109-10 (February 2002). Note: In a revised draft from July 2002, R'_w is replaced by $D_{nT,w}$.

Note: The reference numbers in this Table are not consistent with the reference numbers in the end of the paper.

Table 3: *Sound insulation internally in dwellings – Criteria in European schemes/proposals for sound classification of dwelllings.*

European schemes/proposals for sound classification of dwellings **Criteria for airborne and impact sound insulation internally in dwellings** March 2003			
Country with indication of class denotation and reference	**Required performance for classes** (1) **Airborne sound insulation** R'_w or $R'_w+C_{50-5000}$ [dB]	**Required performance for classes** (1) **Impact sound insulation** $L'_{n,w}$ or $L'_{n,w}+C_{i,50-2500}$ [dB]	**Comments**
Denmark D / C / B / A [6]	None	None	
Norway D / C / B / A [4]	≥ - / - / *43*(*) / *48*(*)	≤ - / - / *63*(*) / *58*(*)	See note (2)
Sweden D / C / B / A [3]	≥ - / - / *40** / *44**	≤ - / - / *68** / *64**	See note (2)
Iceland D / C / B / A [7]	≥- / - / *43** / *48**	≤ - / - / *63** / *58**	See note (2)
Germany VDI I / II / III [2] H = Horizontal V = Vertical **Germany E DIN I / II / III** [9]	H: ≥ 40 / 48 / 48 V: ≥ 50 / 55 / 55 ≥ - / 40 / 40	≤ 56 / 46 / 46 ≤ - / 53 / 53	
France QL / QLAC [1]	None	None	
The Netherlands 5 / 4 / 3 / 2 / 1 [5]	**$D_{nT,w}$ + C** ≥ 12 / 22 / 32 / 42/ 52	**$L'_{n,w}$ + C_i** ≤ 93 / 83 / 73 / 63 / 53	
Estonia D / C / B / A [8]	≥ - / - / *43** / *48**	≤ - / - / *63** / *58**	See note (2)

Notes

(1) The full sets of criteria are found in the references.
*XX**: Numbers in *Italic* and marked with a "*" include the spectrum adaptation terms $C_{50-3150}$ or $C_{i,50-2500}$ as defined in EN ISO 717-1 and 717-2, respectively. For numbers marked with a "(*)" the standard only recommends that $C_{50-3150}$ and $C_{i,50-2500}$ are included in the criteria applied.

(2) At least one habitable room in the dwelling must fulfill the criteria.

References See Table 2.

Considering the classification schemes in Europe there are several discrepancies:

- Concepts used for description of sound insulation and noise criteria
- Number of quality classes and intervals between classes
- Use of low-frequency spectrum adaptation terms according to [6]
- Sound insulation internally in dwellings
- Common or separate quality levels for multi-storey and terraced housing
- Balance between criteria for airborne and impact sound insulation
- Relation to legal requirements

5. CONCLUSIONS

After approx. 50 years with almost no changes in building acoustic requirements in Europe, there seems to be a trend towards stricter requirements, but the process is slow. During the last decade voluntary classification schemes describing different levels of acoustic comfort have been introduced or proposed in 8 countries, thus covering the need to define different quality levels.
A comparison between 18 European countries of the lega1 requirements for sound insulation reveals significant differences. None of the voluntary classification schemes are identical.
The findings do not reflect a harmonised Europe. In the future, efforts should be made to improve the harmonisation of concepts (not necessarily levels), and the requirements for facades should be based on the harmonised environmental noise indicators, see [17].

In order to gather information and share experience more systematically, a working group, EAA TC-RBA WG4 [18], has been established recently (2002). In the future, this working group could advise on how to harmonise the use of concepts for sound insulation.
More noise sources (incl. neighbours' activities) and an increased demand for high quality and comfort together with a trend towards light-weight constructions are contradictory and call for optimising building design using acoustic simulation models, see [19].
The benefits of a harmonisation include facilitating the exchange of information and experience and development of design tools. Based on the experience, classification criteria might be adjusted and optimized.

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[17] Europe - Environment - Noise Policy: http://www.europa.eu.int/comm/environment/noise/home.htm

[18] EAA TC-RBA WG4: "*Sound insulation requirements and sound classification – Harmonization of concepts*". See: http://www.eaa-fenestra.org/index.php?option=displaypage&Itemid=156&op=file&SubMenu= European Acoustical Association (EAA), Technical Committee Room and Building Acoustics (TC-RBA).

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