Sound classification of dwellings – Comparison of schemes in Europe

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Introduction

In most countries in Europe, building regulations specify minimum requirements concerning acoustical conditions for new dwellings. The requirements relate to airborne and impact sound insulation, noise levels from traffic and technical installations as well as other acoustical and noise aspects.

However, complying with legal requirements does not guarantee satisfactory conditions for the occupants in dwellings, and several countries have introduced sound classification schemes with classes intended to reflect different levels of acoustical comfort. Consequently, acoustic requirements for a dwelling can be specified as the legal minimum requirements or - if available - as a specific class in a classification scheme. While legal sound insulation requirements for dwellings have existed for more than 50 years in several countries, schemes describing classes of acoustic quality of dwellings have been introduced during the past 1½ decade.

Sound classification schemes for dwellings exist in nine countries in Europe. The schemes specify - like the building regulations - criteria concerning several acoustic aspects.

This paper presents an overview of the current sound classification schemes for dwellings, and the main criteria for sound insulation between dwellings are described and compared.

Overview sound classification schemes for dwellings

Sound classification schemes in Europe are national schemes, the majority being published by national standardization organizations, see Figure 1. Only in Germany and France, the first countries to prepare and publish such schemes (in 1993 and 1994, respectively), the schemes are published by other organizations.

Figure 1: Most sound classification schemes in Europe are published by national standardization organizations. None of the schemes are identical.

An overview of existing sound classification schemes for dwellings is found in Table 1, and proposals are under preparation in more countries (e.g. Austria and Italy). Like the building codes, the classification schemes specify criteria concerning several acoustic aspects, including:

- Airborne sound insulation between dwellings
- Impact sound insulation between dwellings
- Facade sound insulation (or indoor noise levels from traffic and industry)
- Noise from building services and equipment

In addition, there are several other acoustic criteria. Examples are limits concerning reverberation time in staircases, and sound insulation between staircases and dwellings.

Table 1: European schemes for sound classification of dwellings with indication of link to building codes.

European schemes for sound classification of dwellings				
Country	**Class denotations** (1)	**CS year and references (latest version)**		**BC** (2) **linked to CS**
DK	A / B / C / D	DS 490 (2007)	[1]	**+**
FI	A / B / C / D	SFS 5907 (2004)	[2]	**+**
IS	A / B / C / D	IST 45 (2003)	[3]	**(-)**
NO	A / B / C / D	NS 8175 (2008)	[4]	**+**
SE	A / B / C / D	SS 25267 (2004)	[5]	**+**
LT	A / B / C / D / E	STR 2.01.07 (2003)	[6]	**+**
NL	1 / 2 / 3 / 4 / 5	NEN 1070 (1999)	[7]	**-**
DE	III / II / I	VDI 4100 (2007)	[8]	**-**
FR	QLAC / QL (2)	Qualitel (2008)	[9]	**-**

Abbreviations: BC = Building Code; CS = Classification scheme

Notes:

(1) Classes are indicated in descending order, i.e. the best class first.

(2) Interaction between BC and CS indicated. See also Tables 3 and 4.

Sound insulation requirements and class criteria are expressed by descriptors defined in standards. Within building acoustics, ISO standards are implemented as European (EN) standards and national standards The current international descriptors for evaluation of airborne and impact sound insulation are defined in ISO 717:1996 [10]. A requirement or class criterion for airborne and impact sound insulation may be expressed as the sum of a single-number quantity and a spectrum adaptation term or solely as the single-number quantity. Examples could be:

$D_{nT,w} \geq 55$ dB; $L'_{nT,w} \leq 50$ dB;

$D_{nT,w} + C \geq 55$ dB; $L'_{nT,w} + C_I \leq 50$ dB;

$D_{nT,w} + C_{50\text{-}3150} \geq 55$ dB $L'_{nT,w} + C_{I,50\text{-}2500} \leq 50$ dB

The single-number quantities and the spectrum adaptation terms are derived from values measured according to ISO 140 [11]. The spectrum adaptation terms have been introduced to take into account different spectra of noise sources, cf. [10]. The issue of descriptors is further elaborated in [12].

For some types of buildings, e.g. for light-weight buildings, it is important to include low-frequency spectrum adaptation terms (down to 50 Hz), cf. e.g. [12], or other criteria taking into account low frequencies to obtain a significantly improved correlation between subjective and objective sound insulation.

The regulatory main requirements on airborne and impact sound insulation between dwellings in 24 European countries are presented in [13] and [14]. A comparison between the 24 different countries reveals significant discrepancies descriptors and requirements. For both airborne and impact sound insulation requirements, several descriptors are applied in Europe. For detailed information about sound insulation field descriptors, see [12], or for overview information [13] or [14].

The different classes in classification schemes are intended to reflect different levels of acoustical comfort. Thus, to be able to make a qualified choice of sound class, it is of course relevant to know the degree of acoustical comfort or occupants' satisfaction for the respective classes. As an example, summarized information based on DS 490 is found in Table 2.

Table 2: Occupants' expected satisfaction for different sound classes according to DS 490:2007.

Sound classes describing acoustic conditions in dwellings Information compiled based on DS 490		**Occupants' evaluation**	
Class	**Characteristics**	Good or very good	Poor
A	Excellent acoustic conditions. Occupants will be disturbed only occasionally by sound or noise.	> 90 %	
B	Significant improvement compared to minimum in class C. Occupants may be disturbed sometimes.	70 to 85 %	< 10%
C	Sound class intended as the minimum for new buildings.	50 to 65 %	< 20%
D	Sound class intended for older buildings with less satisfactory acoustic conditions, e.g. for renovated dwellings.	30 to 45 %	25 to 40%
Note: Within each sound class the percentage satisfied or dissatisfied occupants may depend on the type of criterion. The grouping is mainly based on the subjective assessments of airborne and impact sound from adjacent dwellings.			

Another way to characterize sound classes is found in VDI 4100 [8], Table 1, where typical neighbour noises like speech (normal, raised, loud), walking, installations, music, television, parties are listed, and for each type of noise the perception is described corresponding to the three sound classes.

It should be noted that sound insulation is not only a question of comfort, but also about health, cf. [15]. Furthermore, insufficient sound insulation may be the cause of conflicts between neighbours.

Sound classification schemes in Europe – Class criteria

The main criteria for airborne and impact sound insulation between dwellings are found in Tables 3 and 4. The schemes include several other criteria concerning sound insulation and noise levels, see references [1] to [9].

Considering the nine classification schemes in Europe there are several differences:

- Descriptors used to describe sound insulation and noise criteria
- Number and denotations of quality classes and intervals between classes
- Use of low-frequency spectrum adaptation terms according to ISO 717:1996 [10]
- Balance between criteria for airborne and impact sound insulation
- Common or separate quality levels for multi-storey and row housing
- Sound insulation internally in dwellings
- Relation to legal requirements

The status of the classification schemes in relation to the legal requirements varies, cf. the last column in Tables 3 and 4. In some countries there is no link between the building code and the classification scheme. In other countries they are strongly "integrated", and the building code refers to a specific class in the classification standard rather than describing the requirements. By referring to a class, a building code draws attention to the facts that the legal requirements are minimum requirements and that possibilities of voluntary specification and design for better acoustic quality exist. If a classification scheme is not linked to building regulations or to other incentives, its impact may be less strong.

The sound classification schemes in the Nordic countries are based on a common Nordic draft, see [16] and [17], but due to linking to revision of building regulations, the national schemes were finished and published at different times and are unfortunately not identical.

For airborne and impact sound insulation internally in dwellings, the criteria in the nine schemes in Europe are found in [14]. Facade sound insulation class criteria are described in [18] and partly in [19]. For complete information, see [1] to [9].

Further comments related to classification schemes

As an alternative or supplement to extensive classification schemes, some countries have defined a simple set of criteria for increased acoustical comfort, for example added in an annex to the document describing the legal requirements, thus reducing the need for a classification scheme. Such criteria are found in e.g. the Austrian, German, Swiss and Belgian legal requirements, cf. [20].

Table 3: Airborne sound insulation between dwellings. Main criteria in sound classification schemes in Europe.

Airborne sound insulation between dwellings - Main class criteria in dB						
Country [3]	**Class A** **NL: Class 1** **DE: Class III** **FR: N/A**	**Class B** **NL: Class 2** **DE: Class II** **FR: QLAC**	**Class C** **NL: Class 3** **DE: Class I** **FR: QL**	**Class D** **NL: Class 4** **DE: N/A** **FR: N/A**	**Class E** **NL: Class 5** **DE: N/A** **FR: N/A**	**BC reference to CS**
DK	$R'_w + C_{50\text{-}3150} \geq 63$	$R'_w + C_{50\text{-}3150} \geq 58$	**$R'_w \geq 55$**	$R'_w \geq 50$	N/A	Class C
FI	$R'_w + C_{50\text{-}3150} \geq 63$	$R'_w + C_{50\text{-}3150} \geq 58$	**$R'_w \geq 55$**	$R'_w \geq 49$	N/A	Class C
IS	$R'_w + C_{50\text{-}3150} \geq 63$	$R'_w + C_{50\text{-}3150} \geq 58$	$R'_w \geq 55$ [1]	$R'_w \geq 50$	N/A	Class C recommended
NO	$R'_w + C_{50\text{-}5000} \geq 63$	$R'_w + C_{50\text{-}5000} \geq 58$	**$R'_w \geq 55$** [1]	$R'_w \geq 50$	N/A	Class C
SE	$R'_w + C_{50\text{-}3150} \geq 61$	$R'_w + C_{50\text{-}3150} \geq 57$	**$R'_w + C_{50\text{-}3150} \geq 53$**	$R'_w \geq 49$	N/A	Class C
LT	$R'_w + C_{50\text{-}3150} \geq 63$ or $D_{nT,w} + C_{50\text{-}3150} \geq 63$	$R'_w + C_{50\text{-}3150} \geq 58$ or $D_{nT,w} + C_{50\text{-}3150} \geq 58$	**R'_w or $D_{nT,w} \geq 55$** [1]	R'_w or $D_{nT,w} \geq 52$	R'_w or $D_{nT,w} \geq 48$	Class C
NL*	$D_{nT,w} + C \geq 62$	$D_{nT,w} + C \geq 57$	$D_{nT,w} + C \geq 52$	$D_{nT,w} + C \geq 47$	$D_{nT,w} + C \geq 42$	None (BC ~ Class 3)
DE Multi [2]**	H: $R'_w \geq 59$ V: $R'_w \geq 60$	H: $R'_w \geq 56$ V: $R'_w \geq 57$	H: $R'_w \geq 53$ V: $R'_w \geq 54$	N/A	N/A	None (BC ≈ Class I)
DE Row [2]**	$R'_w \geq 68$	$R'_w \geq 63$	$R'_w \geq 57$	N/A	N/A	None (BC ≈ Class I)
FR* **	N/A	$D_{nT,w} + C \geq 56$	$D_{nT,w} + C \geq 53$	N/A	N/A	None [4]

* Classes 1, 2, 3, 4, 5; ** Classes III, II, I; * Classes QLAC, QL

(1) Use of $C_{50\text{-}3150/5000}$ is recommended also in Class C

(2) Multi = Multi-storey housing; Row = Row housing; H = Horizontal; V = Vertical

(3) For references, see Table 1

(4) Class/label QL for airborne sound insulation between dwellings equals BC requirement. For impact sound level, QL is 3 dB stricter than the BC.

Table 4: Impact sound insulation between dwellings. Main criteria in sound classification schemes in Europe.

Impact sound insulation between dwellings - Main class criteria in dB						
Country [3]	**Class A** **NL: Class 1** **DE: Class III** **FR: N/A**	**Class B** **NL: Class 2** **DE: Class II** **FR: QLAC**	**Class C** **NL: Class 3** **DE: Class I** **FR: QL**	**Class D** **NL: Class 4** **DE: N/A** **FR: N/A**	**Class E** **NL: Class 5** **DE: N/A** **FR: N/A**	**BC reference to CS**
DK	$L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	**$L'_{n,w} \leq 53$**	$L'_{n,w} \leq 58$	N/A	Class C
FI	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} \leq 49$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 49$	**$L'_{n,w} \leq 53$** [1]	$L'_{n,w} \leq 63$	N/A	Class C
IS	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	$L'_{n,w} \leq 53$ [1]	$L'_{n,w} \leq 58$	N/A	Class C recommended
NO	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	**$L'_{n,w} \leq 53$** [1]	$L'_{n,w} \leq 58$	N/A	Class C
SE	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	$L'_{n,w} \leq 52$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 52$	**$L'_{n,w} \leq 56$** **$L'_{n,w} + C_{I,50\text{-}2500} \leq 56$**	$L'_{n,w} \leq 60$	N/A	Class C
LT	$L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	**$L'_{n,w} \leq 53$** [1]	$L'_{n,w} \leq 58$	$L'_{n,w} \leq 60$	Class C
NL*	$L'_{nT,w} + C_I \leq 43$	$L'_{nT,w} + C_I \leq 48$	$L'_{nT,w} + C_I \leq 53$	$L'_{nT,w} + C_I \leq 58$	$L'_{nT,w} + C_I \leq 63$	None (BC ~ Class 3)
DE Multi [2]**	$L'_{n,w} \leq 39$	$L'_{n,w} \leq 46$	$L'_{n,w} \leq 53$	N/A	N/A	None (BC ≈ Class I)
DE Row [2]**	$L'_{n,w} \leq 34$	$L'_{n,w} \leq 41$	$L'_{n,w} \leq 48$	N/A	N/A	None (BC ≈ Class I)
FR* **	N/A	$L'_{nT,w} \leq 52$ (QLAC)	$L'_{nT,w} \leq 55$ (QL)	N/A	N/A	None [4]

* Classes 1, 2, 3, 4, 5; ** Classes III, II, I; * Classes QLAC, QL

(1) Use of $C_{I,50\text{-}2500}$ is recommended also in Class C

(2) Multi = Multi-storey housing; Row = Row housing; H = Horizontal; V = Vertical

(3) For references, see Table 1.

(4) Class/label QL for airborne sound insulation between dwellings equals BC requirement. For impact sound level, QL is 3 dB stricter than the BC.

Conclusions

National sound classification schemes for dwellings exist in nine countries in Europe, and proposals are under preparation in more countries. However, due to lack of coordination, there are significant discrepancies between the European classification schemes for dwellings, and none of the schemes are identical. Descriptors, number of quality classes, class denotations, class intervals, levels of classes and the status of the classification schemes in relation to the legal requirements vary. 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.

Although the schemes prove useful on a national basis, the diversity in Europe is an obstacle for exchange of experience and for further development of design tools. The current variety of descriptors and classes also causes trade barriers. The findings do not reflect a harmonized Europe. In the future, efforts should be made to harmonize sound insulation descriptors and preferably also class levels.

National regulatory requirements are decided at a national level, and by harmonizing a classification scheme, each country could choose the class for requirements found appropriate to meet the expectations of the inhabitants, considering also building traditions and other conditions. Although not optimal for exchange of experience and construction data, it could be possible for a country to choose one class for airborne sound and another class for impact sound.

It is important to be aware of that sound insulation is not only a question of comfort, but also about health. Furthermore, insufficient sound insulation may be the cause of conflicts between neighbours.

In order to gather information and share experience more systematically, a working group, EAA TC-RBA WG4 [21], has been established. This working group could advise on use of descriptors for sound insulation as well as choice of class for the legislation.

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