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Sound Classification of Dwellings – A Diversity of National Schemes in Europe

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Summary

Sound classification schemes for dwellings exist in ten countries in Europe, typically prepared and published as national standards. The schemes define quality classes intended to reflect different levels of acoustical comfort. The main criteria concern airborne and impact sound insulation between dwellings, facade sound insulation and installation noise. This paper presents the sound classification schemes in Europe and compares the class criteria for sound insulation between dwellings.

The schemes have been implemented and revised gradually since the early 1990s. However, due to lack of coordination, there are significant discrepancies, and new standards and revisions continue to increase the diversity. Descriptors, number of quality classes, class intervals and class levels vary – as well as the status of the classification schemes in relation to regulatory requirements. In some countries, the building code and the classification standard are incoherent, in other countries strongly "integrated", implying that the building code refers to a specific class in a classification standard rather than describing requirements.

The diversity in Europe is an obstacle for exchange of experience about constructions fulfilling different classes. The current variety of descriptors and classes also causes trade barriers. Thus, there is a need to harmonize characteristics of the schemes, and a European COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions", has been established and runs 2009-2013. The main objectives of TU0901 are to prepare proposals for harmonized sound insulation descriptors and for a European sound classification scheme with a number of quality classes for dwellings.

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1. Introduction

In most countries in Europe, building regulations specify minimum requirements about acoustical conditions for new dwellings, cf. [1], [2], [3]. 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 regulatory requirements does not guarantee satisfactory conditions for the occupants in dwellings, and since the early 1990s, several countries have developed and introduced sound classification schemes with classes intended to reflect different levels of acoustical comfort. Sound classification schemes in Europe are national schemes, the majority being published by national standardization organizations. Only in

Germany and France, the first countries to prepare and publish such schemes, the schemes are published by other organizations. Due to lack of cooperation between countries, the schemes in Europe are very different, thus impeding exchange of experience and causing trade barriers.

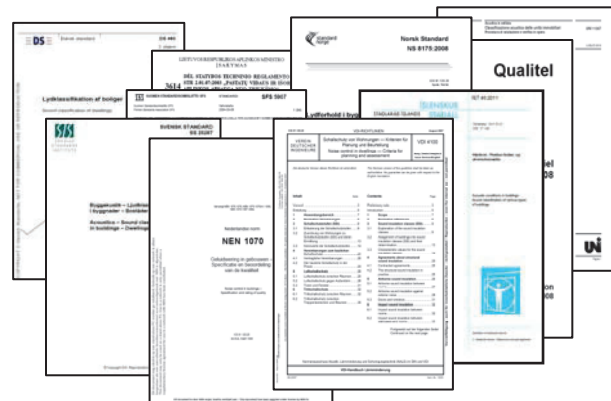


Figure 1 – Most classification schemes in Europe are published by national standardization organizations.

2. Overview sound classification schemes for dwellings

Sound classification schemes for dwellings exist at present in 10 countries in Europe, [4-13]. Several of these schemes also include classification of other types of premises, e.g. schools, kindergarten, offices, hotels and hospitals.

An overview of existing sound classification schemes for dwellings is found in Table I. Proposals are under preparation in more countries, e.g. Austria [14] and Spain [15].

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, the schemes specify class criteria concerning other acoustic aspects. Examples are reverberation time in staircases, sound insulation between staircases and dwellings, outdoor noise.

Table I. European schemes for sound classification of dwellings, relation to building codes and indication of classes intended for new and "old" dwellings. Status March 2011.

Country	Class denotations ⁽¹⁾	CS Reference (latest version)	Link BC to CS	BC Reference to CS	Comment	Classes for new dwellings	Classes for "old" dwellings	
DK	A/B/C/D	DS 490 (2007)	[4]	+	Class C	A, B, C	D	
FI	A/B/C/D	SFS 5907 (2004)	[5]	(-)	None	BC = Class C	A, B, C	D
IS	A/B/C/D	IST 45 (2011)	[6]	+ ⁽³⁾	Class C ⁽³⁾	(3)	A, B, C	D
NO	A/B/C/D	NS 8175 (2008)	[7]	+	Class C	A, B, C	D	
SE	A/B/C/D	SS 25267 (2004)	[8]	+	Class C	A, B, C	D	
LT	A/B/C/D/E	STR 2.01.07 (2003)	[9]	+	Class C	A, B, C	D, E	
NL	I/II/III/IV/V	NEN 1070 (1999)	[10]	-	None	BC ~ Class III	I/II/III	IV, V
IT	I/II/III/IV	UNI 11367 (2010)	[11]	-	None	BC ~ Class III	I/II/III	IV
DE	III/II/I	VDI 4100 (2007) (5)	[12]	-	None	BC ~ Class I	III, II, I	None
FR	QLAC/QL ⁽²⁾	Qualitel (2008)	[13]	-	None	(4)	QLAC/QL	None

Abbreviations: BC = Building Code (regulatory requirements); CS = Classification scheme
 (1) Classes are indicated in descending order, i.e. the best class first.
 (2) The indicated class denotations are applied for sound insulation between dwellings, but there is only one performance level for e.g. facade sound insulation.
 (3) Criteria as for Class C were published as "recommended values" in 1998. A proposal for a new building code includes a reference to Class C, approval expected late 2011. For more information, see [16].
 (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.
 (5) Moreover, the German Society of Acoustics (DEGA) has published a recommendation for labelling of acoustic quality of new and existing buildings. The labelling system has seven classes described by the letters A-F and a colour code, the lower classes intended for old buildings.
 Ref.: DEGA-Empfehlung 103. "Schallschutz im Wohnungsbau – Schallschutzausweis", March 2009.
<http://dega-schallschutzausweis.de/>.

When comparing the information in Table I, some schemes may appear similar, e.g. NL and IT, but they are very different. Even the Nordic schemes are more different than appearing from Table I.

For each scheme listed in Table I, the relation to the national building code is indicated as well as the classes intended for new and for existing (old/renovated and other not new) housing, respectively. The regulatory main requirements for airborne and impact sound insulation between dwellings in 24 European countries are presented in [1-2]. Some updates and extension to more countries are found in [3]. Minimum sound

insulation as defined in regulations protects only people with a normal sensitivity against noise against disturbance caused by "normal" neighbour activities. Verbal explanations of performance make this clear to occupants. It also becomes evident that occupants themselves might need to cut down their activities out of consideration for their neighbours.

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 acoustical comfort or occupants' satisfaction

for the respective classes. As an example, summarized information based on DS 490 is found in Table II. Another way to characterize sound classes is found in VDI 4100 [12], 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. [1] and [17]. Furthermore, insufficient sound insulation may be the cause of conflicts between neighbours.

Table II. Occupants' expected satisfaction for different sound classes according to DS 490:2007. Summary based on information in DS 490.

Sound insulation between dwellings Main class criteria in DS 490:2007			Characteristics of DS 490 sound classes for dwellings and occupants' expected evaluation Information compiled based on DS 490		
Class	Airborne	Impact	Sound class descriptions	Good or very good	Poor
A	$R'_w + C_{50-3150} \geq 63$ dB	$L'_{n,w} \leq 43$ dB and $L'_{n,w} + C_{1,50-2500} \leq 43$ dB	Excellent acoustic conditions. Occupants will be disturbed only occasionally by sound or noise.	> 90 %	
B	$R'_w + C_{50-3150} \geq 58$ dB	$L'_{n,w} \leq 48$ dB and $L'_{n,w} + C_{1,50-2500} \leq 48$ dB	Significant improvement compared to minimum in class C. Occupants may be disturbed sometimes.	70 to 85 %	< 10 %
C	$R'_w \geq 55$ dB	$L'_{n,w} \leq 53$ dB	Sound class intended as the minimum for new buildings.	50 to 65 %	< 20 %
D	$R'_w \geq 50$ dB	$L'_{n,w} \leq 58$ dB	Sound class intended for older buildings with less satisfactory acoustic conditions, e.g. for renovated dwellings.	30 to 45 %	25 to 40 %
Reference: DS 490:2007, "Lydklassifikation af boliger" (Sound classification of dwellings).			Note: Within each sound class the percentage of 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.		

3. Sound classification schemes in Europe – Class criteria

The main criteria for airborne and impact sound insulation between dwellings are found in Tables III and IV. More details about the schemes and class criteria are found in [18], including class criteria for sound insulation internally in dwellings. Facade sound insulation class criteria are found in [19]. Aspects related to sound classes for renovated housing are described in [20].

The status of the classification schemes in relation to the legal requirements varies, cf. Table I and the last column in Tables III and IV. 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 [1], but due to revision of building regulations, the national schemes were finished and published at different times and are unfortunately not identical, see Tables III and IV.

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 [21]. The single-number quantities and the spectrum adaptation terms are derived from values measured according to ISO 140 [22].

The spectrum adaptation terms have been introduced to take into account different spectra of noise sources, cf. [21]. The issue of descriptors is further elaborated in [23]. 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. [1-2], or other criteria taking into account low frequencies to obtain a significantly improved correlation between subjective and objective sound insulation.

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

Airborne sound insulation between dwellings - Main class criteria in dB						
Status March 2011						
Country ⁽⁴⁾	Class A NL: Class I IT: Class I DE: Class III FR: N/A	Class B NL: Class II IT: Class II DE: Class II FR: QLAC	Class C NL: Class III IT: Class III DE: Class I FR: QL	Class D NL: Class IV IT: Class IV DE: N/A FR: N/A	LT: Class E NL: Class V IT: N/A DE: N/A FR: N/A	BC reference to CS
DK	$R'_w + C_{50-3150} \geq 63$	$R'_w + C_{50-3150} \geq 58$	$R'_w \geq 55$	$R'_w \geq 50$	N/A	Class C
FI	$R'_w + C_{50-3150} \geq 63$	$R'_w + C_{50-3150} \geq 58$	$R'_w \geq 55$	$R'_w \geq 49$	N/A	None (BC = Class C)
IS	$R'_w + C_{50-3150} \geq 63$	$R'_w + C_{50-3150} \geq 58$	$R'_w \geq 55^{(1)}$	$R'_w \geq 50$	N/A	Class C ⁽²⁾
NO	$R'_w + C_{50-5000} \geq 63$	$R'_w + C_{50-5000} \geq 58$	$R'_w \geq 55^{(1)}$	$R'_w \geq 50$	N/A	Class C
SE	$R'_w + C_{50-3150} \geq 61$	$R'_w + C_{50-3150} \geq 57$	$R'_w + C_{50-3150} \geq 53$	$R'_w \geq 49$	N/A	Class C
LT	$R'_w + C_{50-3150} \geq 63$ or $D_{nT,w} + C_{50-3150} \geq 63$	$R'_w + C_{50-3150} \geq 58$ or $D_{nT,w} + C_{50-3150} \geq 58$	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 III)
IT**	$R'_w \geq 56$	$R'_w \geq 53$	$R'_w \geq 50$	$R'_w \geq 45$	N/A	None
DE*** Multi ⁽³⁾	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 ⁽³⁾	$R_w \geq 68$	$R_w \geq 63$	$R_w \geq 57$	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

* Classes I, II, III, IV, V; ** Classes I, II, III, IV; *** Classes III, II, I; **** Classes QLAC, QL
 (1) Use of $C_{50-3150/5000}$ is recommended also in Class C. Iceland: If applied, the limit values may be reduced by 2 dB.
 (2) Expected in new building regulations end 2011.
 (3) Multi = Multi-storey housing; Row = Row housing; H = Horizontal; V = Vertical
 (4) For references, see Table I.

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

Impact sound insulation between dwellings - Main class criteria in dB						
Status March 2011						
Country ⁽⁴⁾	Class A NL: Class I IT: Class I DE: Class III FR: N/A	Class B NL: Class II IT: Class II DE: Class II FR: QLAC	Class C NL: Class III IT: Class III DE: Class I FR: QL	Class D NL: Class IV IT: Class IV DE: N/A FR: N/A	LT: Class E NL: Class V IT: N/A DE: N/A FR: N/A	BC reference to CS
DK	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{1,50-2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{1,50-2500} \leq 48$	$L'_{n,w} \leq 53$	$L'_{n,w} \leq 58$	N/A	Class C
FI	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{1,50-2500} \leq 43$	$L'_{n,w} \leq 49$ and $L'_{n,w} + C_{1,50-2500} \leq 49$	$L'_{n,w} \leq 53^{(1)}$	$L'_{n,w} \leq 63$	N/A	None (BC = Class C)
IS	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{1,50-2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{1,50-2500} \leq 48$	$L'_{n,w} \leq 53^{(1)}$	$L'_{n,w} \leq 58$	N/A	Class C ⁽²⁾
NO	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{1,50-2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{1,50-2500} \leq 48$	$L'_{n,w} \leq 53^{(1)}$	$L'_{n,w} \leq 58$	N/A	Class C
SE	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{1,50-2500} \leq 48$	$L'_{n,w} \leq 52$ and $L'_{n,w} + C_{1,50-2500} \leq 52$	$L'_{n,w} \leq 56$ $L'_{n,w} + C_{1,50-2500} \leq 56$	$L'_{n,w} \leq 60$	N/A	Class C
LT	$L'_{n,w} + C_{1,50-2500} \leq 43$	$L'_{n,w} + C_{1,50-2500} \leq 48$	$L'_{n,w} \leq 53^{(1)}$	$L'_{n,w} \leq 58$	$L'_{n,w} \leq 60$	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 III)
IT**	$L'_{n,w} \leq 53$	$L'_{n,w} \leq 58$	$L'_{n,w} \leq 63$	$L'_{n,w} \leq 68$	N/A	None
DE*** Multi ⁽³⁾	$L'_{n,w} \leq 39$	$L'_{n,w} \leq 46$	$L'_{n,w} \leq 53$	N/A	N/A	None (BC ≈ Class I)
DE*** Row ⁽³⁾	$L'_{n,w} \leq 34$	$L'_{n,w} \leq 41$	$L'_{n,w} \leq 48$	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

* Classes I, II, III, IV, V; ** Classes I, II, III, IV; *** Classes III, II, I; **** Classes QLAC, QL
 (1) Use of $C_{1,50-2500}$ is recommended also in Class C.
 (2) Expected in new building regulations end 2011.
 (3) Multi = Multi-storey housing; Row = Row housing; H = Horizontal; V = Vertical
 (4) For references, see Table I.

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. Austria, Germany, Switzerland and Belgium, cf. [1].

Comparing the 10 classification schemes in Europe, several differences are found:

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

An indication of the variety of descriptors applied is seen from Tables III and IV. Further descriptors are applied in the proposed Austrian and Spanish schemes, see [14-15].

Steps between classes are 3-7 dB, if comparing classes corresponding to building codes and higher. The most striking differences between countries and between classes are found in impact sound criteria.

Even in the Nordic countries, the classification schemes have diversified, although a common Nordic proposal existed in the 1990s. Regional efforts to exchange experience and harmonize requirements are made in more national and transnational projects, e.g. in Silent Spaces [24] aiming at reducing noise and vibrations in buildings and dwellings, especially light-weight buildings, and contribute to harmonization of requirements in Sweden and Denmark.

4. Conclusions and perspectives

Acoustic requirements for a dwelling can be specified as the legal minimum requirements or - if available - as a specific class in a classification describing different quality classes to meet different needs of activities and quietness in the home.

National sound classification schemes for dwellings exist in 10 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. Although the schemes might prove useful on a national basis, the diversity in Europe is an obstacle for exchange of construction experience and data. In addition, the current variety of descriptors and classes causes trade barriers.

To improve the situation, efforts should be made to harmonize sound insulation descriptors and preferably also class levels. Most classification schemes seem – quite understandably – to be rooted in national regulatory requirements and building traditions.

National regulatory requirements are decided at a national level. Looking into the future, harmonization of sound insulation requirements seems unrealistic. However, by reducing the number of sound insulation descriptors and by preparing a harmonized European classification scheme with a number of quality classes, each member state could select for regulations a "harmonized" class, which is 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. However, research is needed to improve knowledge about relations between class criteria and occupants' subjective evaluation for different construction types.

To initiate harmonization and coordinate research, a European Action, COST TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions" [25], was established in 2009 and runs until 2013.

TU0901 main objectives:

- Propose harmonized descriptors for airborne and impact sound insulation.
- Propose a European acoustic classification scheme for dwellings.

Until now (March 2011), 29 European countries and institutions from three non-COST countries (New Zealand, Australia and Canada) have been approved as members of TU0901, and about 90 people have been nominated for the management committee and working groups. Participating COST countries are: AT, BE, HR, CZ, DK, EE, FI, MK, FR, DE, GR, HU, IS, IT, LT, MT, NL, NO, PL, PT, RO, RS, SK, SI, ES, SE, CH, TR, UK.

For detailed information about the Action, the MoU, the parties, the MC members and the activities, see [25]. At WG meetings, workshops etc., experience with regulations, classification schemes and constructions is shared among TU0901 member countries – as e.g. at the EAA & TU0901 symposium in 2010 [26], thus preparing the ground for harmonization in Europe.

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