Sound classification of dwellings – Quality class ranges and intervals in national schemes in Europe

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Summary
National schemes for sound classification of dwellings exist in more than ten countries in Europe, typically published as national standards. The schemes define quality classes reflecting different levels of acoustical comfort. Main criteria concern airborne and impact sound insulation between dwellings, facade sound insulation and installation noise.
The schemes have been developed, implemented and revised gradually since the early 1990s. However, due to lack of coordination between countries, there are significant discrepancies, and new standards and revisions continue to increase the diversity. Descriptors, range of quality levels, number of quality classes, class intervals, denotations and descriptions vary across Europe.
The diversity is an obstacle for exchange of experience about constructions fulfilling different classes, implying also trade barriers. Thus, a harmonized classification scheme is needed, and a European COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions", has been established and runs 2009-2013, one of the main objectives being to prepare a proposal for a European sound classification scheme with a number of quality classes for dwellings.
However, each of the national classification schemes represents the result of extensive efforts, considerations and discussions, often during many years, and a change cannot be accepted easily. Thus, it is important to analyze present schemes and involve all countries in the preparation of a European proposal. This paper deals with the sound insulation between dwellings and focuses on comparison of range of quality levels in the national schemes, number of quality classes and class intervals.

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1. Introduction

Building regulations specify minimum requirements about acoustical conditions for new dwellings in most countries in Europe, cf. [1, 2, 3]. However, complying with regulatory requirements does not guarantee satisfactory conditions for the occupants, and since the early 1990s, several countries have developed and introduced sound classification schemes with classes reflecting different levels of acoustical comfort. The purpose is to make it easier for developers to specify and for users to require a standardized acoustic quality better than the quality defined by regulations.
Sound classification schemes in Europe are national schemes, the majority being published by national standardization organizations. Due to lack of coordination between countries, the schemes in Europe are very different, cf. [4, 5], thus impeding exchange of experience and causing trade barriers.

Due to harmonization efforts, it is important to analyze differences between existing schemes.
This paper focuses on the quality class ranges and intervals for airborne and impact sound insulation between dwellings.

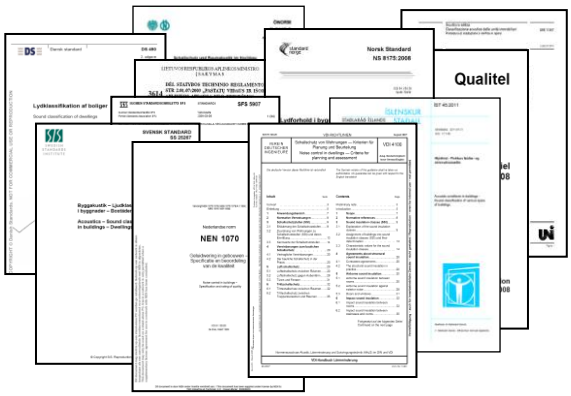

Figure 1. Most classification schemes in Europe are published by national standardization organizations.

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2. Overview sound classification schemes for dwellings

Sound classification schemes for dwellings exist at present in 11 countries in Europe, [6-16]. Several of these schemes also include classification of other types of premises, e.g. schools, kindergarten, healthcare facilities and offices.

An overview of existing sound classification schemes for dwellings is found in Table I. For each scheme listed, the class denotations and the relation to the national building code are indicated as well as the classes intended for new and for existing (old/renovated) housing, respectively. 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 also draws attention to the facts that the regulatory requirements are minimum requirements and that voluntary specification and design of a better acoustic quality is a possibility.

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 internally in dwellings and 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 2012.

Country[6]	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)	[6]	+	Class C		A, B, C	D
FI	A / B / C / D	SFS 5907 (2004)	[7]	–	N/A	BC = Class C	A, B, C	D
IS	A / B / C / D	IST 45 (2011)	[8]	+	Class C		A, B, C	D
NO	A / B / C / D	NS 8175 (2008)	[9]	+	Class C		A, B, C	D
SE	A / B / C / D	SS 25267 (2004)	[10]	+	Class C		A, B, C	D
LT	A / B / C / D / E	STR 2.01.07 (2003)	[11]	+	Class C		A, B, C	D, E
IT	I / II / III / IV	UNI 11367 (2010)	[12]	–	N/A	BC ~ Class III	I / II / III	IV
DE[4]	III / II / I	VDI 4100 (2007)[5]	[13]	–	N/A	BC ~ Class I	III, II, I	None
AT	A / B / C / D / E	ÖNORM B 8115-5 (2012)	[14]	–	N/A	BC = Class C	A, B, C	D, E
NL	I / II / III / IV / V	NEN 1070 (1999)	[15]	–	N/A	BC ~ Class III	I / II / III	IV, V
FR	QLAC / QL[2]	Qualitel (2012)	[16]	–	N/A	(3)	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) Class/label QL for airborne sound insulation between dwellings equals BC requirement. For impact sound level, QL is 3 dB stricter than the BC.
(4) Moreover, the German Society of Acoustics (DEGA) has published a recommendation [17] for acoustic labelling of dwellings. The system has seven classes A*-F and a colour code, the lower classes intended for old buildings.
(5) VDI 4100 is under revision. Change of sound insulation descriptors expected (from R'_w and $L'_{n,w}$ to $D_{nT,w}$ and $L'_{nT,w}$).
(6) The Spanish Acoustical Society (AECOR) has prepared a proposal for classification of dwellings, cf. [18], with classes A, B, C, the lowest class corresponding to the building regulations.

3. Sound insulation between dwellings – Quality class criteria, ranges and intervals in national schemes in Europe

Main criteria for airborne and impact sound insulation between dwellings are found in Tables II and III. More details about the schemes and class criteria are found in [4] and in [5, 19], including class criteria for sound insulation internally in dwellings. Facade sound insulation class criteria are found in [5, 20]. Aspects related to sound classes for renovated housing are described in [21].

Sound insulation class criteria are expressed by the current international descriptors for evaluation of airborne and impact sound insulation as defined in ISO 717:1996 [22]. The single-number quantities and the spectrum adaptation terms are derived from values measured according to ISO 140 [23] or calculated according to EN 12354 [24].

Table II. 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 2012						
Country [4]	**Class A** **NL, IT: Class I** **DE: Class III** **FR: N/A**	**Class B** **NL, IT: Class II** **DE: Class II** **FR: QLAC**	**Class C** **NL, IT: Class III** **DE: Class I** **FR: QL**	**Class D** **NL, IT: Class IV** **DE, FR: N/A**	**LT, AT: Class E** **NL: Class V** **IT, DE, 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	None (BC = 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
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
IT*	$R'_w \geq 56$	$R'_w \geq 53$	$R'_w \geq 50$	$R'_w \geq 45$	N/A	None (BC ~ Class III
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)
AT	$D_{nT,w} + C_{50\text{-}3150} \geq 60$	$D_{nT,w} + C_{50\text{-}3150} \geq 55$	C_R [3]: $D_{nT,w} \geq 55$ $D_{nT,w} \geq 60$	$D_{nT,w} \geq 50$	$D_{nT,w} < 50$	None (BC = 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)
FR****	N/A	$D_{nT,w} + C \geq 55$ Row [2]: $D_{nT,w} + C \geq 58$	$D_{nT,w} + C \geq 53$	N/A	N/A	None

* Classes I, II, III, IV; ** Classes III, II, I; *** Classes I, II, III, IV, V; **** Classes QLAC, QL
(1) Use of $C_{50\text{-}3150/5000}$ is recommended also in Class C. If applied, the limit value may be reduced by 2 dB.
(2) Multi = Multi-storey housing; Row = Row housing; H = Horizontal; V = Vertical
(3) For row housing there is a special criterion to match the building regulations, and the class is denoted C_R.
(4) For references, see Table I.

Table III. 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 2012						
Country [4]	**Class A** **NL, IT: Class I** **DE: Class III** **FR: N/A**	**Class B** **NL, IT: Class II** **DE: Class II** **FR: QLAC**	**Class C** **NL, IT: Class III** **DE: Class I** **FR: QL**	**Class D** **NL, IT: Class IV** **DE, FR: N/A**	**LT, AT: Class E** **NL: Class V** **IT, DE, FR: N/A**	**BC reference to CS**
DK	$L'_{n,w} \leq 43$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$	$L'_{n,w} \leq 48$ and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$	$L'_{n,w} \leq 53$	$L'_{n,w} \leq 58$	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	None (BC = 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
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
IT*	$L'_{n,w} \leq 53$	$L'_{n,w} \leq 58$	$L'_{n,w} \leq 63$	$L'_{n,w} \leq 68$	N/A	None (BC ~ Class III
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)
AT	$L'_{nT,w} \leq 38$ and $L'_{nT,w} + C_I \leq 43$ $L'_{nT,w} + C_{I,50\text{-}2500} \leq 48$	$L'_{nT,w} \leq 43$ and $L'_{nT,w} + C_I \leq 43$	C_R [3]: $L'_{nT,w} \leq 48$ $L'_{nT,w} \leq 43$	$L'_{nT,w} \leq 53$	$L'_{nT,w} > 53$	None (BC = 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)
FR****	N/A	$L'_{nT,w} \leq 52$	$L'_{nT,w} \leq 55$	N/A	N/A	None

* Classes I, II, III, IV; ** Classes III, II, I; *** Classes I, II, III, IV, V; **** 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 row housing there is a special criterion to match the building regulations, and the class is denoted C_R.
(4) For references, see Table I.

In Figures 2 and 3 are found graphical comparisons of classes in the 11 European countries. The special criteria for row housing in DE, AT and FR have not been included.

The regulatory requirements for the same countries have been added as separate columns in Figures 2 and 3. Data are from [4], where more information is found about the requirements.

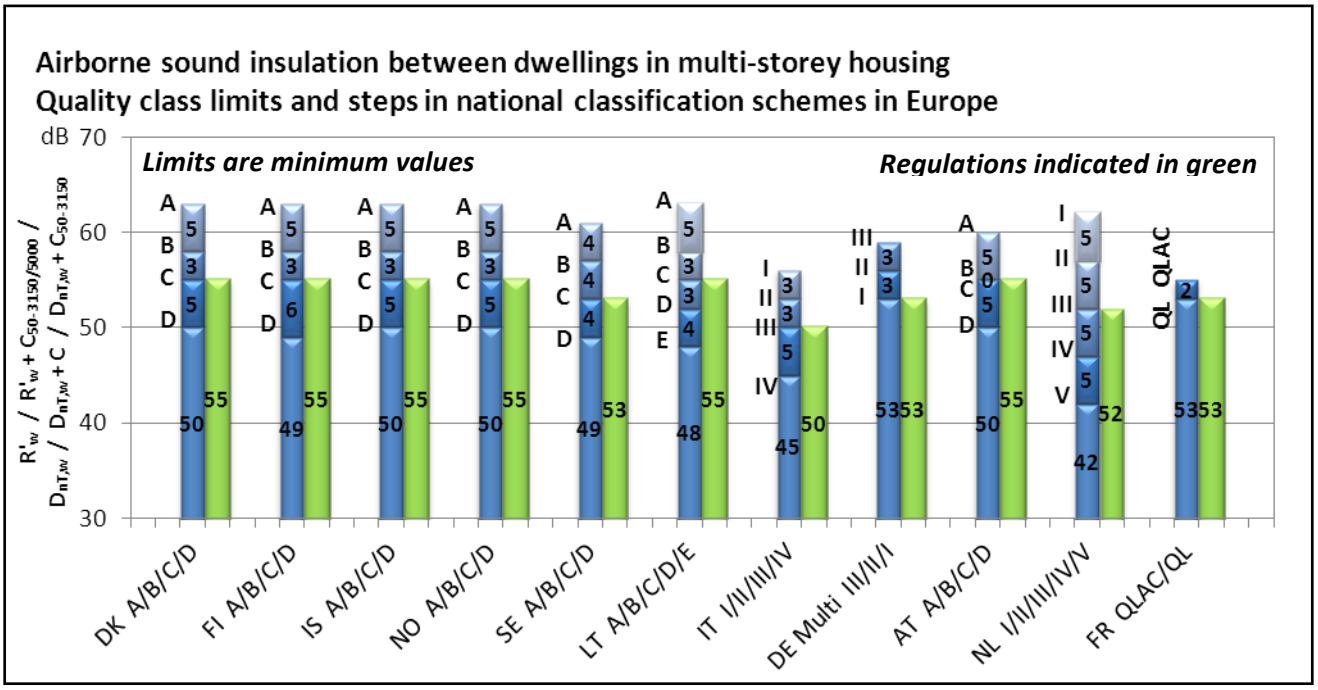

Figure 2. Airborne sound insulation quality class limits (min values) and steps in national classification schemes in Europe. Note: The actual numbers have been applied without any conversion between different descriptors. The specific class criteria are found in Table II.

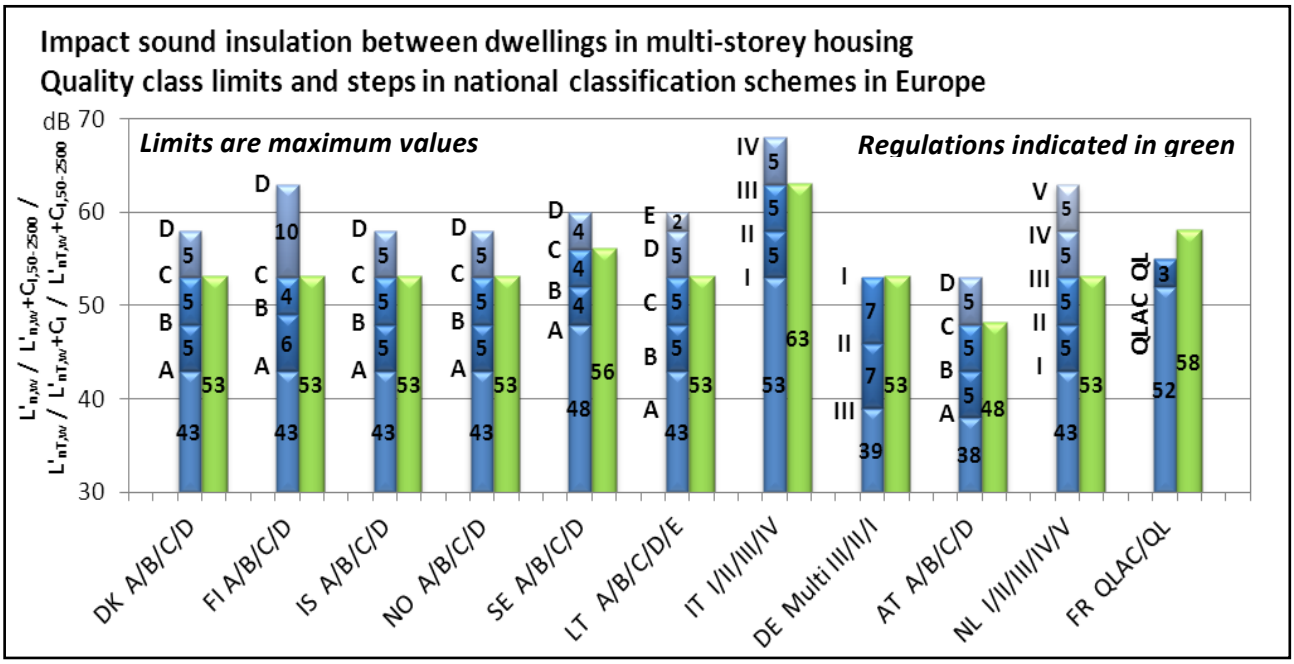

Figure 3. Impact sound insulation quality class limits (max values) and steps in national classification schemes in Europe. Note: The actual numbers have been applied without any conversion between different descriptors. The specific class criteria are found in Table III.

Comparing the data from the 11 classification schemes in Europe, cf. Tables I-III and Figures 2-3, several differences are found:

- Number of quality classes (2 to 5) and denotations (see table I)
- Range of quality classes (2-20 dB for airborne, 3-20 dB for impact) and level of range
- Intervals between classes (2-6 dB for airborne, 3-10 dB for impact)
- Descriptors used for sound insulation criteria
- Use of low-frequency spectrum adaptation terms according to ISO 717:1996
- Common or separate quality levels for multi-storey and row housing
- Relation to regulatory requirements

The majority of the classification schemes include criteria for sound insulation internally in dwellings, cf. [5, 19] and [6-16].

The most striking differences between countries and between classes are found in impact sound criteria, e.g. the best class in [12] corresponds exactly to the lowest class in [13] and [14], cf. Figure 3 and table III, and for [16] there is just a 1 dB margin.

The issue of descriptors is further elaborated in [2, 25]. For some types of buildings, e.g. for light-weight buildings, it is important, cf. e.g. references in [1-2], to include low-frequency spectrum adaptation terms (down to 50 Hz) or other relevant criteria taking into account low frequencies.

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].

4. Conclusions and perspectives

National sound classification schemes for dwellings exist in 11 countries in Europe. 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 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 may cause trade barriers.

Even in the Nordic countries, the classification schemes have diversified, cf. [5], although a common Nordic proposal existed in the 1990s.

To improve the situation, efforts should be made to harmonize sound insulation descriptors and preferably also class levels. The present classification schemes are – quite understandably – rooted in national building traditions and regulatory requirements, which are decided at a national level.

Regional efforts to exchange experience and harmonize requirements are made in more national and transnational projects, e.g. in Silent Spaces [26] aiming at reducing noise and vibrations in buildings and dwellings, especially light-weight buildings, and contribute to harmonization of requirements in Sweden and Denmark.

To initiate harmonization and coordinate research internationally, a European Action, COST TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions" [27], was established in 2009 and runs until 2013. The TU0901 main objectives are to prepare proposals for harmonized descriptors for airborne and impact sound insulation and for a European acoustic classification scheme for dwellings.

About 90 experts from 29 European countries and from institutions in three non-COST countries (New Zealand, Australia and Canada) have been nominated for the management committee and working groups. At WG meetings, symposia like e.g. [28], workshops etc., experience with regulations, classification schemes and constructions are shared among TU0901 member countries**.**

Looking into the future, harmonization of regulatory sound insulation requirements seems unrealistic. Nevertheless, 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 the "harmonized" class, which is found most appropriate to meet the expectations of the inhabitants, considering also building traditions and other conditions.

Based on a comparison of the existing schemes, it seems as if a starting point for further negotiations could be a scheme having four classes, the lowest one for existing housing, with about 4 dB intervals between airborne classes and about 5 dB intervals between impact classes. A big issue will be, if a low-frequency rating should be included in all classes or only the upper classes.

However, research is needed to improve knowledge about relations between class criteria and occupants' subjective evaluation of different construction types.

The present paper provides input to discussions in the Nordic countries as well as to Silent Spaces [26] and TU0901 [27].

Acknowledgements

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