International proposal for an acoustic classification scheme for dwellings – Background and perspectives

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ABSTRACT

Acoustic classification schemes specify different quality levels for acoustic conditions. Regulations and classification schemes for dwellings typically include criteria for airborne and impact sound insulation, façade sound insulation and service equipment noise. However, although important for quality of life, information about acoustic conditions is rarely available, neither for new or existing housing. Regulatory acoustic requirements will, if enforced, ensure a corresponding quality for new dwellings, but satisfactory conditions for occupants are not guaranteed. Consequently, several European countries have introduced classification schemes. The schemes typically include four classes. Comparative studies have shown significant discrepancies between countries due to national development of schemes. The diversity is an obstacle for exchange of construction experience for different classes, implying also trade barriers. Thus, a harmonized classification scheme would be useful, and the European COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions", running 2009-2013 with members from 32 countries, including three overseas countries, had as one of the main objectives preparation of a proposal for a harmonized acoustic classification scheme. The proposal developed has been approved as an ISO/TC43/SC2 work item, and a working group established. This paper describes the proposal, the background and the perspectives.

Keywords: Sound insulation, acoustic classification, dwellings, housing, standards
I-INCE Classification of Subjects Number(s): 51.4, 51.5, 81.2

1. INTRODUCTION & BACKGROUND

Comparative studies of regulatory sound insulation requirements in Europe [1,2] and acoustic classification schemes [3] show that sound insulation descriptors, regulatory requirements and classification schemes in Europe represent a high degree of diversity. Regulatory sound insulation requirements for dwellings exist in more than 30 countries in Europe. Classification schemes exist in several countries. In some countries, sound insulation requirements have existed since the 1950s. The first classification schemes for dwellings were implemented in the early 1990s. The studies conclude that harmonization is needed for descriptors and sound insulation classes to facilitate exchange of data and experience between countries and to reduce trade barriers.

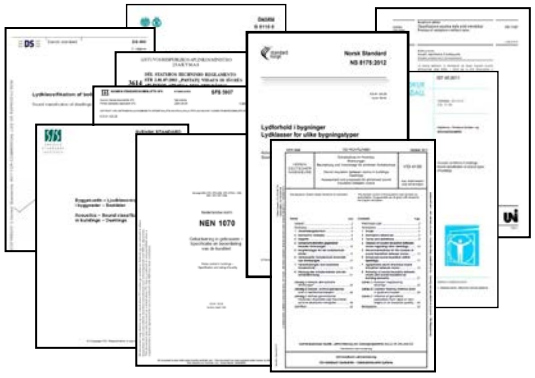

Figure 1 – Classification schemes in Europe are published by national standardization organizations since the 1990es. Only in Germany, schemes have been published by "private" organizations. An overview of schemes is found in Table 1.

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It is on this background, the European research network, COST Action TU0901 “Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions” [4] was established to initiate and support a process towards a common framework.

COST TU0901 (running 2009-2013) considered the main tool to be an acoustic classification scheme for dwellings – implying definition of a number of quality classes – combined with knowledge about housing constructions complying with the class criteria. Regulations is a national issue and not subject to harmonization. However, like the building codes, 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) and noise from building services and equipment.

During the four years lifetime of COST TU0901, research cooperation and discussions have taken place between experts from the 29 European countries and 3 overseas countries participating in COST TU0901. The findings from COST TU0901 are presented in two books with the joint main title “Building acoustics throughout Europe”, see [5, 6].

The TU0901 main objectives are:

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

An important part of the background is also that social surveys in several European countries have shown that many occupants of multi-storey housing are considerably annoyed by noise from neighbours' activities, see e.g. [5, Ch.2] and results from social surveys in several countries in [7].

This paper will focus on class criteria for airborne and impact sound insulation between dwellings. Details on other issues can be found in references.

2. SOUND INSULATION DESCRIPTORS

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 international descriptors for evaluation of airborne and impact sound insulation are defined in ISO 717 [8]. Although being ISO members, USA and Canada apply ASTM standards.

For more information about history and details of sound insulation descriptors, see [1] and Ch.2 in [5]. For both airborne and impact sound insulation requirements and class criteria, several descriptors are applied in Europe. Examples of descriptors applied:

- Airborne sound insulation, e.g.: R'_w ; $R'_w + C$; $R'_w + C_{50\text{-}3150}$; $D_{nT,w}$; $D_{nT,w} + C$
- Impact sound pressure level, e.g.: $L'_{n,w}$; $L'_{n,w} + C_{I,50\text{-}2500}$; $L'_{nT,w}$; $L'_{nT,w} + C_I$

Besides, there are variants; recommendations and special rules. Exact details about existing classification schemes are found in [10-19], and details of regulations are found in the national building codes.

3. ACOUSTIC CLASSIFICATION SCHEMES IN EUROPE - HISTORY AND STATUS

Acoustic classification schemes describe different quality classes to meet different needs of activities and quietness in the home. Here, a classification scheme is understood as a set of minimum three classes with different acoustic performance levels. Using this definition, schemes for dwellings exist at present in 10 countries in Europe [10-19]. An overview of existing acoustic classification schemes for dwellings is found in Table 1. For each scheme, information is found about class denotations, publication year since the first versions and relation to the national building code. The schemes specify class criteria concerning several acoustic aspects. The schemes and main class criteria are described in more detail in [3], and for facades in [20, 21].

When comparing the information in Table 1, some schemes may appear similar, e.g. NL and IT, but they are very different. Even the Nordic schemes differ more than appearing from Table 1, see [20].

The different classes in the classification schemes are intended to reflect different levels of acoustical protection. Thus, to be able to make a qualified choice of a class, it is of course relevant to know the occupants' satisfaction or perception of different noise sources for each of the acoustic classes. In Table 2 is found an example of sound insulation criteria in the four classes of DS 490 [10] and the estimated evaluation (% good, very good, poor). In VDI 4100 [18] is included a table with verbal descriptions of perception of several noise sources for each of the three acoustic classes.

The majority of acoustic classification schemes include criteria for sound insulation internally in dwellings, see class criteria in [22] and [10-19] for complete, updated information about details. See also Section 4.3 for indication of discussion points related to the proposal prepared by TU0901.

Table 1 – European schemes for sound classification of dwellings and relation to building codes. A new proposal prepared by COST TU0901 and approved as WI in ISO has been included for comparison. Status July 2014.

Country	Class denotations(1)	Year of publication	CS Reference (latest version)	Link BC to CS	BC Reference to CS	Comment
DK	A / B / C / D	2001/2007	DS 490 (2007)	+	Class C	
FI	A / B / C / D	2004	SFS 5907 (2004)	–	N/A	BC = Class C
IS	A / B / C / D	2003/2011	IST 45 (2011)	+	Class C	
NO	A / B / C / D	1997/2005/2008/2012	NS 8175 (2012)	+	Class C	
SE	A / B / C / D	1996/1998/2004/(*)	SS 25267 (2004)	+		BC ~ Class C
LT	A / B / C / D / E	2003	STR 2.01.07 (2003)	+	Class C	
IT	I / II / III / IV	2010	UNI 11367 (2010)	–	N/A	BC ~ Class III
DE (2)	III / II / I	1994/2007/2012	VDI 4100 (2012) (3)	–	N/A	
AT	A / B / C / D / E	2012	ÔNORM B 8115-5 (2012	–	N/A	BC = Class C
NL	I / II / III / IV / V	1999	NEN 1070 (1999)	–	N/A	BC ~ Class III
COST TU0901	A / B / C / D / E / F and npd	Proposal 2013	ISO/TC43/SC2 (2013) See [5], Ch.5, or [25]	N/A	N/A	(4)

Abbreviations: BC = Building Code (regulatory requirements); CS = Classification scheme
(1) Classes are indicated in descending order, i.e. the best class first.
(2) Moreover, the German Society of Acoustics (DEGA) has published a recommendation (DEGA-Empfehlung 103, "Schallschutz im Wohnungsbau – Schallschutzausweiz", DEGA, March 2009) for acoustic labelling of dwellings. The system has seven classes A*-F and a colour code,
(3) The revised version of VDI 4100 published in 2012 changed descriptors from R'_w and $L'_{n,w}$ to $D_{nT,w}$ and $L'_{nT,}$ as had been discussed for years for the regulations. Also the class criteria were made stricter, and all classes are now stricter than regulations (before the lowest class corresponded to regulations).
(4) Proposal prepared by TU0901 [5], Ch.5.4. New Work Item for standardization in ISO, see [25, 26].
(*) Draft ftSS 25267 for a revised classification scheme submitted for enquiry in May 2014.

Table 2 – Occupants' expected satisfaction for different sound classes according to DS 490:2007 [10]. Summary based on information in DS 490.

Sound insulation between dwellings Main class criteria in DS 490:2007		
Class	**Airborne**	**Impact**
A	$R'_w + C_{50\text{-}3150} \geq 63$ dB	$L'_{n,w} \leq 43$ dB and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$ dB
B	$R'_w + C_{50\text{-}3150} \geq 58$ dB	$L'_{n,w} \leq 48$ dB and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$ dB
C	$R'_w \geq 55$ dB	$L'_{n,w} \leq 53$ dB
D	$R'_w \geq 50$ dB	$L'_{n,w} \leq 58$ dB
Reference: DS 490:2007, "Lydklassifikation af boliger" (Sound classification of dwellings).		

Characteristics of DS 490 sound classes for dwellings and occupants' expected evaluation Information compiled based on DS 490		
Sound class descriptions	Good or very good	**Poor**
Excellent acoustic conditions. Occupants will be disturbed only occasionally by sound or noise.	**> 90 %**	
Significant improvement compared to minimum in class C. Occupants may be disturbed sometimes.	**70 to 85 %**	**< 10 %**
Sound class intended as the minimum for new buildings.	**50 to 65 %**	**< 20 %**
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 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.		

Comparing the data from the 10 classification schemes in Europe, see Table 1, Figures 2-3, main class criteria in [3] and detailed criteria in [10-19], several differences are found:

- Number of quality classes (3 to 5) and denotations (see Table 1)
- Range of quality classes (8-20 dB for airborne, 12-20 dB for impact) and position, see Figs. 2-3
- Steps between classes (3-6 dB for airborne, 2-10 dB for impact)
- Descriptors used for sound insulation criteria
- Use of low-frequency spectrum adaptation terms according to ISO 717:2013 [8]
- Common or separate quality levels for multi-storey and row housing
- Relation to regulatory requirements
- Sound insulation internally in dwellings

4. PROPOSAL FOR A JOINT ACOUSTIC CLASSIFICATION SCHEME

The proposal developed by COST TU0901 is based on studies of the existing schemes for dwellings and other publications as well as discussions of experience and needs. One of the main tasks was decisions on descriptors, including translation of descriptors applied in different countries as described in [23-24].

The proposal was finalized in November 2013 and submitted by DIN/Germany as an NWIP to ISO/TC43/SC2. The WI was approved in March 2014. The full proposal can be found in [5], Ch.5, which also describes the development process, or in [25].

The main characteristics of the TU0901 proposal for an acoustic classification scheme for dwellings are:

- It includes class criteria for airborne and impact sound insulation, noise from traffic and other external sources, noise from service equipment, plus reverberation time in stairwells as an option.
- It defines six classes (from A to F) with 4 dB steps between classes. For each class, there is a choice between sound insulation criteria down to 50 Hz or the common lower limit of 100 Hz.

4.1 Examples of sound insulation class criteria

Examples of tables with class criteria are found in Tables 3 and 4 related to airborne sound insulation and impact sound level, respectively. Although descriptors are based on existing ISO standards, ISO 717 [8] and measurements according to [9], a simpler denotation has been used to avoid criteria indicated as a sum.

A comparison with existing schemes is found in Section 4.2. Some discussion points have been identified, see Section 4.3.

Table 3 – Airborne sound insulation between dwellings and other rooms. Class limits[(1),(2)]. From [25].

Type of space	**Class A** $D_{nT,50}$ **(dB)**	**Class B** $D_{nT,50}$ **(dB)**	**Class C** $D_{nT,50}$ **(dB)**	**Class D** $D_{nT,50}$ **(dB)**	**Class E** $D_{nT,50}$ **(dB)**	**Class F** $D_{nT,50}$ **(dB)**
Between a dwelling and premises with noisy activities[(3)]	≥ 68	≥ 64	≥ 60	≥ 56	≥ 52	≥ 48
Between a dwelling and other dwellings and rooms outside the dwelling	≥ 62	≥ 58	≥ 54	≥ 50	≥ 46	≥ 42

NOTES
(1) $D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$
(2) As an alternative to $D_{nT,50}$, the performance can be estimated for all construction types by the currently more common descriptor $D_{nT,100} = D_{nT,w} + C$, cf. Clause 3. If $D_{nT,100}$ is applied, the class denotation is X_{100}, eg. B_{100}.
(3) Premises with noisy activities are rooms for shared services like laundries, central boiler house, joint/commercial kitchens or commercial premises like shops, workshops or cafés. However, in each case, noise levels must be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques etc. Offices are normally not considered as noisy premises, and the same criteria as for dwellings apply.

Table 4 – Impact sound pressure level in dwellings. Class limits[(1),(2),(3)]. From [25].

Type of space	**Class A** $L'_{nT,50}$ **(dB)**	**Class B** $L'_{nT,50}$ **(dB)**	**Class C** $L'_{nT,50}$ **(dB)**	**Class D** $L'_{nT,50}$ **(dB)**	**Class E** $L'_{nT,50}$ **(dB)**	**Class F** $L'_{nT,50}$ **(dB)**
In dwellings from premises with noisy activities[(4)]	≤ 38	≤ 42	≤ 46	≤ 50	≤ 54	≤ 58
In dwellings from other dwellings	≤ 44	≤ 48	≤ 52	≤ 56	≤ 60	≤ 64
In dwellings: - from common stairwells and access areas - balconies, terraces, bath, toilet not belonging to own dwelling	≤ 48	≤ 52	≤ 56	≤ 60	≤ 64	≤ 70

NOTES
(1) $L'_{nT,50} = L'_{nT,w} + C_{I,50\text{-}2500}$
(2) The same limit values are to be fulfilled by $L'_{nT,w}$.
(3) As an alternative to $L'_{nT,50}$, the performance can be estimated for all types of constructions by the currently more common descriptor $L'_{nT,100} = L'_{nT,w} + C_I$, cf. Clause 3. If $L'_{nT,100}$ is applied, the class denotation is X_{100}, eg. B_{100}.
(4) Premises with noisy activities are rooms for shared services like laundries, central boiler house, joint/commercial kitchens or commercial premises like shops, workshops or cafés. However, in each case, noise levels must be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques etc. Offices are normally not considered as noisy premises, and the same criteria as for dwellings apply.

4.2 Comparison with existing classification schemes

Comparisons between the TU0901 proposal for an acoustic classification scheme (ACS) and the 10 existing ACS in Europe are shown in Figures 2 and 3, although no conversions between descriptors have been made. While for airborne sound, the existing schemes are within the range of the TU0901 ACS proposal, some countries exceed the TU0901 range for impact sound in different directions. The most striking differences between countries are found in impact sound criteria, e.g. the best class in IT [17] corresponds approx. to the lowest class in DE [18] and AT [19]. It could be interesting to know, whether e.g. the strict criteria in DE [18] for multi-storey housing are ever used, and the row housing criteria are even stricter. Furthermore, it is relevant to investigate the need for impact sound protection in those countries allowing quite high impact levels - cf. [5], Ch.2.4 Figures 2.2 and 2.3 - outside the TU0901 range shown in Figure 3, as each country should choose a class as the national regulatory limit.

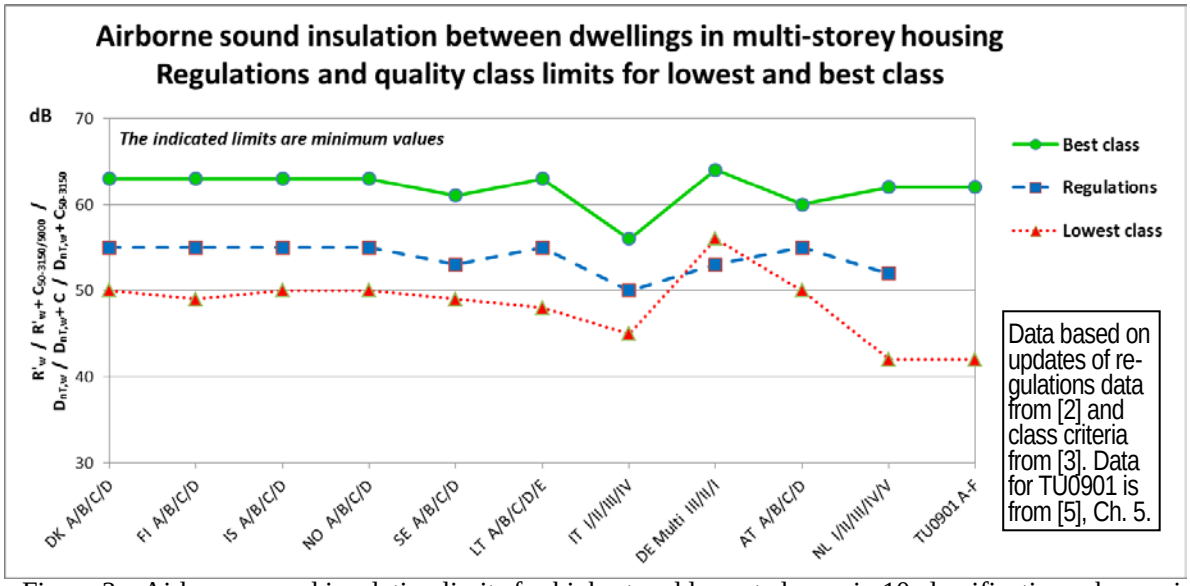

Figure 2 – Airborne sound insulation limits for highest and lowest classes in 10 classification schemes in Europe and regulatory requirements for the same countries. TU0901 class limits for highest and lowest class shown in the right side for comparison. Note: The diversity of descriptors appears from the Y-axis label. The graphs present the numbers only. No conversions between descriptors have been applied.

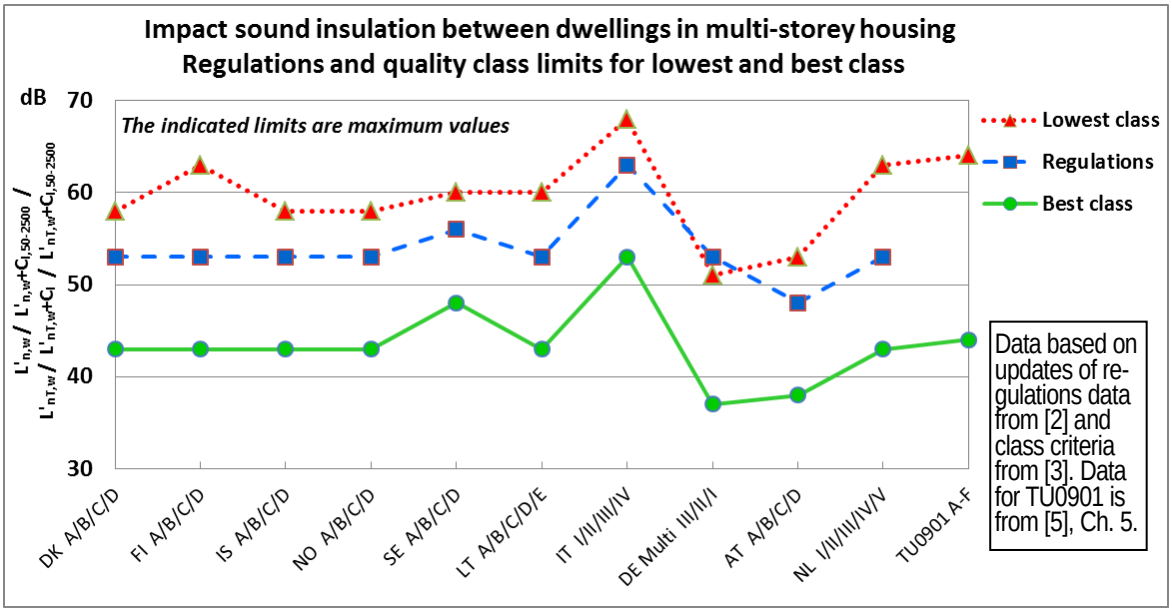

Figure 3 – Impact sound insulation limits for highest and lowest classes in 10 classification schemes in Europe and regulatory requirements for the same countries. TU0901 class limits for highest and lowest class shown in the right side for comparison. Note: The diversity of descriptors appears from the Y-axis label. The graphs present the numbers only. No conversions between descriptors have been applied.

4.3 Discussion points for the ISO working group

During the discussions in TU0901, when digging into details and philosophies of existing regulations and classification schemes, it became clear that some details of the new proposal for a classification scheme needed wider discussions, further studies or more time for considerations and adaptation to a new way of making such a scheme. When finalizing the TU0901 proposal for a classification scheme, the following issues were identified as points for discussions in the ISO WG:

- Low-frequency sound insulation rating to be included in all classes, none of the classes or e.g. only in the upper classes?
- Are the sound insulation limit values and range for classes A-F, see Tables 3-4, appropriate for different types of constructions, or should the criteria be adjusted?
- Criteria for airborne and impact sound insulation between stairwells and dwellings. Should they be stricter or less strict than between dwellings? How much?
- Reverberation time in stairwells.
- How many different limits for service equipment noise? Descriptors for equivalent, max or other ways? How to group different noise sources?
- Should limits on traffic noise level indoor be expressed directly as limits for traffic noise indoor or as minimum values for the facade as a function of the outdoor traffic noise level? Descriptors?
- Traffic noise on outdoor areas to be included in the classification scheme?
- Sound insulation internally in dwellings.
- Verification procedure for compliance with class criteria, including how to integrate calculations.

The discussions will of course include choices and experience from existing schemes. Table 5 shows e.g. to which extent, sound insulation internally in dwellings is included.

Table 5 – Overview of extent of class criteria for sound insulation internally in dwellings in existing acoustic classification schemes for dwellings.

Country	Classification scheme	Classes	Sound insulation internally in dwellings
DK	DS 490:2007	A / B / C / D	–
FI	SFS 5907:2004	A / B / C / D	Class A, B
IS	IST 45:2011	A / B / C / D	Class A, B
NO	NS 8175:2008	A / B / C / D	Class A, B
SE	SS 25267:2004	A / B / C / D	Class A, B
LT	STR 2.01.07 (2003)	A / B / C / D / E	Class A, B
IT	UNI 11367 (2010)	I / II / III / IV	–
DE [2]	VDI 4100 (2012) [3]	III / II / I	Class III, II
AT	ÖNORM B 8115-5 (2012)	A / B / C / D / E	Class A, B
NL	NEN 1070 (1999) [5]	I / II / III / IV / V	Class I / II / III / IV / V
TU0901	Proposal in [25]	A / B / C / D / E / F and npd	–

The ISO/TC43/SC2/WG29 can start work in the fall 2014, after response on call for experts. In parallel with discussion on the above-mentioned points, further research results will be collected and discussed, e.g. [28] describing a new single number rating for impact sound, including frequencies down to 20 Hz.

5. CONCLUSIONS & PERSPECTIVES

Acoustic classification schemes for dwellings exist in 10 countries in Europe and with highly different class criteria, see Section 3, thus impeding exchange of knowledge about constructions relevant for different classes. Some of the schemes are quite new, but unfortunately, there is no sign of increasing harmonization, rather the contrary, i.e. evidence for an even more diverse situation in Europe. More schemes are under development or consideration in other countries, e.g. in France, see [27]. Thus, there seems to be an increasing interest and need for acoustic classification schemes.

A proposal for a" harmonized" acoustic classification scheme for dwellings has been developed by COST Action TU0901 and approved as Work Item by ISO/TC43/SC2.

New housing must meet the needs of the people and offer protection against noise sources. Also for existing housing, sound insulation aspects should be taken into account, especially when renovating housing. - Harmonization of sound insulation requirements is unrealistic, since regulations is a national issue. However, by preparing a joint classification scheme with a number of quality classes, countries could select a "harmonized" class for regulations, fitting the national needs and conditions.

The main uses and benefits of a joint acoustic classification scheme for dwellings are:

- A residential building can be classified, if all dwellings fulfil criteria. Dwellings can also be classified individually, and even an individual room can be classified.
- Specification of acoustic conditions in new housing and in existing housing, before and after renovation – in both situations an analogy to energy labelling.
- Information to occupants of dwellings, including prospective tenants or buyers.
- Consideration by the legislators as a basis for a national set of requirements.
- Reference for sustainability marking or labelling, especially considering that nowadays several organizations are developing sustainability criteria, including acoustic ones.
- Awareness of acoustic conditions in housing and possibilities for improvement – many people think there is nothing to do about poor sound insulation.
- Awareness and knowledge among buyers could motivate builders to improve acoustic conditions.

Several existing acoustic classification schemes (about half) also include classification of other types of premises, e.g. schools, kindergarten, offices, hotels and hospitals, see Table 6.

Table 6 – Simplified overview of building types in existing acoustic classification schemes

Country	Classification scheme (CS)		Dwellings	Schools	Kinder-garten	Healthcare facilities	Offices	Other	No. of pages
DK	DS 490:2007		+	–	–	–	–	–	12 pp
FI	SFS 5907:2004		+	+	+	+	+	+	34 pp
IS	IST 45:2011		+	+	+	+	+	+	37 pp
NO	NS 8175:2008		+	+	+	+	+	+	41 pp
SE	SS 25267:2004		+	–	–	–	–	–	48 pp
	SS 25268:2007		–	+	+	+	+	+	39 pp
LT	STR 2.01.07 (2003)		+	+	+	+	+	+	18 pp
IT	UNI 11367 (2010)		+	+	+	+	+	+	100 pp
DE [2]	VDI 4100 (2012) [3]		+	–	–	–	–	–	33 pp
AT	ÖNORM B 8115-5 (201		+	–	–	–	–	–	20 pp
NL	NEN 1070 (1999) [5]		+	–	–	–	–	–	22 pp
TU0901	Proposal [25]		+	–	–	–	–	–	

Note: Table subject to errors due to insufficient language skills and different ways of categorizing buildings.

Dependent on the interest and experience among members in the coming ISO WG, it might be considered to propose work items for other building types like schools, kindergarten, healthcare facilities and offices which are already included in several existing, national classification schemes.

Acoustic class information could be considered as an acoustic analogy to energy labelling, now widely used, and an acoustic classification standard would enable labelling of acoustic conditions on equal terms with other qualities for new as well as existing housing.

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