MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Developing an international acoustic classification scheme for dwellings – From chaos & challenges to compromises & consensus?

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ABSTRACT

Acoustic regulations and classification schemes for dwellings typically include criteria for sound insulation and service equipment noise. Regulations specify minimum requirements, while classification schemes have quality classes reflecting different acoustical comfort/protection levels. Acoustic regulations and classification schemes were developed without coordination between countries, and comparative studies have shown that acoustic descriptors and limit values differ widely. In addition, classification schemes represent a diversity of class intervals, ranges and denotations. The situation looks like CHAOS and is an obstacle for exchange of construction experience, implying also trade barriers. In 2008, an initiative towards harmonization led to establishing the European COST Action TU0901 (2009-2013) with members from 32 countries. One of the results was a draft international acoustic classification scheme, which subsequently became WI in ISO/TC43/SC2. However, due to various, different long-lasting national traditions causing resistance to changes, there were several CHALLENGES on the road. Nevertheless, over time discussions were leading to improved mutual understanding and more COMPROMISES, but obstacles still exist and the final steps will hopefully lead to a reasonable CONSENSUS, since a joint international document increases awareness on acoustics among authorities, builders and building industry and provides a common ground for collecting experiences for future discussions, research and revisions.

Keywords: Building Acoustics, Regulations, Acoustic Classification, Labelling
I-INCE Classification of Subject Number: 81, 83, 86, 89

1. INTRODUCTION

The need for protection against noise in residential buildings is a well-known issue, and building acoustic regulations for housing exists in most countries in Europe and in many countries worldwide. In some countries, besides having developed national building acoustic regulations, a national acoustic classification scheme (abbreviated ACS hereinafter) for dwellings has been developed. However, there is a wide variety of acoustic descriptors applied in the different regulations and acoustic classification schemes, as explained in [1-4]

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for sound insulation between dwellings. Acoustic regulations, guidelines and classification criteria are typically about: Airborne sound insulation between rooms; Impact sound insulation between rooms; Facade sound insulation; Service equipment noise; Reverberation time or sound absorption.

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 main standards being [5-9]. Outside Europe, building acoustic standards referred to may be from ISO or from other standardization organizations. In this paper, results from comparative studies are mainly from Europe and primarily about airborne and impact sound insulation between dwellings, the international sound insulation descriptors being defined in ISO 717 [5]. The current situation in Europe for national ACS is illustrated in Figure 1 showing front pages of several national classification standards individually developed without coordination between countries and with widely different contents.

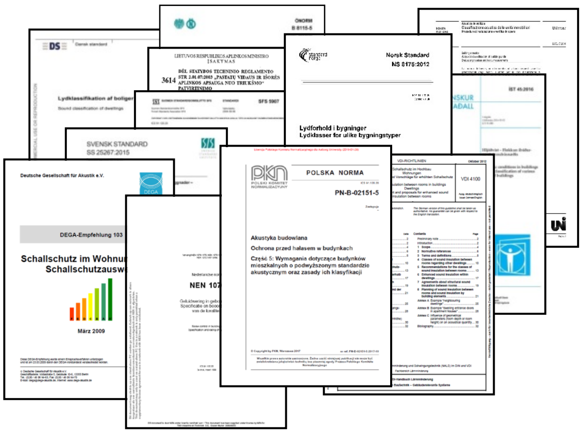

Figure 1 – Classification schemes in Europe have been published since the 1990es, most of them by national standardization organizations. Only in Germany, schemes have been published by "private" organizations. An overview of schemes is found in Table 4.

International discussions on sound insulation descriptors have taken place as long as building acoustic regulations have existed, but intensified in the 1970es, escalated in the 1980es, and continued since then, see e.g. [3] for a brief information about the ISO 717 history. Considering the need for more harmonization, an EAA TC-RBA WG "Sound Insulation Requirements and Sound Classification - Harmonization of descriptors" was established in 2002. Following several discussions and conference papers, e.g. [1-2], an international, more formal upgrade of discussions was found desirable, and in 2008, an initiative towards the harmonization of building acoustics "language" and "tools" at an international level, led to an application to COST. After approval in 2009, the European COST Action TU0901 (2009-2013) was established with members from 32 countries, see [10], and with two main objectives, namely a proposal for harmonized building acoustic descriptors and a proposal for a European classification scheme for dwellings. Descriptions of COST Action TU0901, the WGs and activities as well as external cooperation are found in [10-12]. Analysis of existing classification schemes had a high priority. Examples of papers are [13] and [14].

One of the TU0901 results was a draft international ACS based on a set of proposed harmonized acoustic descriptors, see [15] and [16]. The draft ACS produced within COST TU0901 was submitted by DIN/Germany to ISO/TC 43/SC 2 as a formal NWIP request about developing a standardized acoustic classification scheme for housing. A voting among SC 2 member countries was made, the NWIP was approved as ISO/WI 19488 and WG 29 was established, aiming at – based on the COST TU0901 proposal as a starting document – to develop an ISO ACS. WG29 started its work, and the first official meeting was held in January 2015.

The development of any international standard is a complicated task, no matter what the subject may be. Aside from all the technical issues which shall be considered, there are always other process issues to take into account. The CHAOS & CHALLENGES as well as the COMPROMISES will be explained and some good reasons for CONSENSUS described.

2. ACOUSTIC REGULATIONS AND CLASSIFICATION: INTERNATIONAL CHAOS

The diversity of existing sound insulation descriptors, regulatory requirements and acoustic classification schemes has been presented in several papers. In addition to references in Section 1, see results from newer studies in [17-20]. An updated summary of the current situation is presented below, mainly related to sound insulation between dwellings. For façade sound insulation and service equipment noise, see a few comments in Section 3 about challenges and compromises.

2.1 CHAOS concerning sound insulation descriptors in ISO 717 and regulations

From the references mentioned above, it is known that there is a wide variety of sound insulation descriptors included in existing building acoustic regulations. Considering airborne, impact and façade sound insulation, the widespread has become so large due to spectral adaptation terms in ISO 717. In Table 1 is found an overview of current basic sound insulation descriptors and spectrum adaptation terms. Sound insulation descriptors applied in national sound insulation requirements for dwellings are shown in Table 2 for 31 countries in Europe.

Table 1 – Overview ISO 717 descriptors for evaluation of sound insulation in buildings. Note: The sound insulation descriptors are the same in the 1996 and 2013 versions of ISO 717.

ISO 717:2013 descriptors for evaluation of field sound insulation	Airborne sound insulation between rooms (ISO 717-1) (b)	Airborne sound insulation of facades (a) (ISO 717-1) (b)	Impact sound insulation between rooms (ISO 717-2) (b)
Basic descriptors (single-number quantities)	R'_w $D_{n,w}$ $D_{nT,w}$	R'_w $D_{n,w}$ $D_{nT,w}$	$L'_{n,w}$ $L'_{nT,w}$
Spectrum adaptation terms (listed according to intended main applications)	*None* C $C_{50-3150}$ $C_{100-5000}$ $C_{50-5000}$	*None* C C_{tr} $C_{50-3150}$ $C_{tr,50-3150}$ $C_{100-5000}$ $C_{tr,100-5000}$ $C_{50-5000}$ $C_{tr,50-5000}$	*None* C_I $C_{I,50-2500}$
Total number of descriptors	3 x 5 = 15	3 x 9 = 27	2 x 3 = 6
Notes (a) For facades, the complete indices for R'_w , $D_{n,w}$, $D_{nT,w}$ are found in ISO 717. (b) For simplicity, only 1/3 octave quantities and C-terms are included in the table, although some countries allow 1/1 octave measurements for field check.			

Table 2 – Sound insulation descriptors applied for regulatory requirements between dwellings in 31 countries in Europe. Status Febr. 2019. Update from [14]. Graphical presentations are found in [18].

Airborne sound		Impact sound	
No. of countries	**Descriptor**	**No. of countries**	**Descriptor**
15	R'_w	17	$L'_{n,w}$
7	$D_{nT,w}$	9	$L'_{nT,w}$
3	$R'_w + C$	2	$L'_{nT,w} + C_I$
3	$D_{nT,w} + C$	2	$L'_{nT,w} + C_{I,50-2500}$
1	$D_{nT,w} + C_{50-3150}$	1	L'_w
1	$D_{nT,A}$ ($\approx D_{nT,w} + C$)	?	Variants
1	$D_{nT,w} + C_{tr}$	?	Recommendations
?	Variants	?	Special rules
?	Recommendations		
?	Special rules		

2.2 CHAOS concerning acoustic classification schemes

Acoustic classification schemes (ACS) define a number of quality classes reflecting different levels of acoustic comfort and protection, se illustration in Table 3. The ACS are national and very different due to lack of coordination between countries and thus impeding exchange of experience and causing trade barriers.

When COST TU0901 was launched in 2009, national acoustic classification schemes existed in 10 countries in Europe. As of February 2019, there are 12 countries with 13 ACSs for housing, see [21-33], and at least one other ACS is under development, [34]. Table 4 summarizes the status of ACSs in Europe and makes it easy to observe the diversity of ACSs, among these number of classes and denotations. The table shows the relation to building regulations and number of classes below and above regulations. Steps between classes and total range of classes are described in [13] and [17], although not completely up-to-date. Tables with sound insulation descriptors (Febr. 2019) for all classes are found in [20].

Table 3 – Range of acoustic quality classes using various, partly fictive ranges and denotations.

	Acoustic quality class						
High acoustic protection and comfort	A	B	C	D	E	F	Low acoustic protection and comfort
	III	II	I				
			a	b	c	d	
		A	B	C	D		

Table 4 – European schemes for acoustic classification of dwellings, [21-33], relation to building regulations and class information. ISO/FDIS 19488 (2018), [35], included for comparison.

Acoustic classification of dwellings - Schemes in Europe and relation to building codes – Status Feb. 2019								
Country	Year of publication	ACS Reference (latest version)	Class denotations(1)	BR link to CS	BR ref. to ACS & Comments	No. of classes	No. of classes > BR	No. of classes < BR
DK	2001 / 2007 / 2018	DS 490 (2018)	A / B / C / D / E / F	+	Class C	6	2	3
FI	2004	SFS 5907 (2004)	A / B / C / D	–	N/A (BR > Class C)	4	2	~ 1½
IS	2003 / 2011 / 2016	IST 45 (2016)	A / B / C / D	+	Class C	4	2	1
NO	1997 / 2005 / 2008 / 2012	NS 8175 (2012)	A / B / C / D	+	Class C	4	2	1
SE	1996 / 1998 / 2004 / 2015	SS 25267 (2015) (4)	A / B / C / D	–	N/A (Class C = BR (4))	4	2	1
LT	2003	STR 2.01.07 (2003)	A / B / C / D / E	+	Class C	5	2	2+npd
IT	2010	UNI 11367 (2010)	I / II / III / IV	–	N/A (BR ~ Class III	4	2	1
DE	1994 / 2007 / 2012	VDI 4100 (2012) (2)	III / II / I	–	N/A (BR < Class I (2))	3	~ 3	~ 0
DEGA(3)	2009 / 2018	DEGA Empfehlung 103 (2018) (3)	A*/ A / B / C / D / E / (F)	–	N/A (BR ~ Class D (3))	6+npd	4	1+npd
AT	2012	ÖNORM B 8115-5 (2012)	A / B / C / D / (E)	–	N/A (BR = Class C)	4+npd	2	1+npd
NL	1999	NEN 1070 (1999)	I / II / III / IV / V	–	N/A (BR ~ Class III)	5	2	2
PL	2017	PN-B-02151-5:2017 (4)	AQ-4 / AQ-3 / AQ-2 / AQ-1 / AQ-0	–	N/A (Class AQ-0 = BR (4))	5	4	0
TR	2017	Noise Protection and sound insulation in Buildings(5)	A/B/C/D/E/F	+	Class C	6	2	3
ISO/WI	ISO/WI 19488 since 2014	ISO/FDIS 19488 (Aug. 2018)	A/B/C/D/E/F and npd	N/A	N/A (See note(6))	6+npd	N/A	N/A

Abbreviations: BR = Building Regulations (regulatory requirements); ACS = Acoustic Classification Scheme

(1) Classes are indicated in descending order, i.e. the best class first. Denotations in brackets correspond to npd.

(2) 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), and class criteria were made stricter, i.e. above and regulations. After tightening of DIN 4109-1 in 2016, the basic criteria for the lowest class I for MS-housing are again similar to regulations, but VDI 4100 has additional criteria, e.g. on internal sound insulation.

(3) In addition to VDI 4100, the German Society of Acoustics (DEGA) has published a recommendation, DEGA-Empfehlung 103, "Schallschutz im Wohnungsbau – Schallschutzausweiz". For MS-housing, Class D criteria in general correspond to regulations, but there are additional criteria.

(4) SS 25267 and PN-B-02151-5 do not include class C and AQ-0 criteria, respectively, but refer to values in the BR.

(5) "Noise Protection and Sound Insulation in Buildings" www.resmigazete.gov.tr/eskiler/2017/05/20170531-7.htm (May 2017).

(6) Original proposal prepared by COST TU0901 in 2013. ISO/WI 19488 from 2014, ISO/FDIS Aug. 2018 and same limits in ISO/NP TS 19488 Jan. 2019.

Comparing the data from the classification schemes in Europe, see Table 4, detailed class criteria in [21-33] and overview tables in [20], several differences are found, e.g. the following:

– Number of quality classes (3 to 6) and denotations. Note: "npd" not counted as a class.
– Descriptors used for sound insulation criteria.
– Use of low-frequency spectrum adaptation terms according to ISO 717:2013.
– Intervals between classes.
– Range of quality classes (~ 8 to 22 dB for airborne, ~ 14 to 30 dB for impact) and position.
– Relation to regulatory requirements.

Other relevant comparisons between the acoustic classification schemes are e.g. about:

– Sound insulation internally in dwellings
– Sound absorption in stairwells
– Outdoor noise levels
– Classification certificate

When considering the information in Table 4, some schemes may appear similar, e.g. NL and IT, but they are very different. Even the Nordic schemes originating in the same Nordic proposal are more different than they appear from Table 4, see also [18] and [20].

The sound insulation descriptors applied in acoustic classification schemes for housing [21-33] in Europe are the following:

Airborne: R'_w; $R'_w + C_{50\text{-}3150}$; $R'_w + C_{50\text{-}5000}$; $R'_w + C_{tr}$; $D_{nT,w}$; $D_{nT,w} + C$; $D_{nT,w} + C_{50\text{-}3150}$
Impact: $L'_{n,w}$; $L'_{n,w} + C_{I,50\text{-}2500}$; $L'_{nT,w}$; $L'_{nT,w} + C_I$; $L'_{nT,w} + C_{I,50\text{-}2500}$

A summary of findings from comparative studies in Europe of low-frequency sound insulation descriptors in acoustic regulations, recommendations and acoustic classification schemes is found in Table 5. It is seen that 7 of 12 countries have included LF-descriptors in their acoustic classification schemes.

Table 5 – Number of countries in Europe using ISO 717 low-frequency sound insulation descriptors.

LF descriptors in acoustic regulations, recommendations and acoustic quality classes in Europe			
Number of countries	Acoustic regulations		Acoustic quality classes
	Mandatory	Recommended	
Airborne	1 (SE)	3 (IS, NO. LT) + 1 (1)	7 (2)
Impact	2 (SE & FI)	3 (IS, NO. LT) + 1 (1)	7 (2)

(1) In DK, it is recommended using LF-descriptors in case of light-weight constructions (walls < 100 kg/m^2, floors < 250 kg/m^2), [21].
(2) Classes A and B in DK, FI, IS, NO, SE, AT: LF-descriptors included.

Until now, only two countries have LF-descriptors included in acoustic requirements for housing: Sweden since 1999 and Finland since 2018 [36]. However, more countries have recommendations, see Table 5, and several countries have LF-descriptors included in the acoustic quality classes stricter than regulations, cf. Table 5 and detailed tables in [20] with descriptors for all classes in the existing national classification schemes. In general, there seems to be increasing attention to the LF-performance, cf. e.g. the journal and conference papers [37-42] and recent literature related to acoustic regulations, e.g. Ch. 3 in [43], and to construction data, see [44]. The LF-concern seems especially strong for impact sound.

3. ISO/WI 19488 ACS: TECHNICAL CHALLENGES AND COMPROMISES

This section summarizes the most important and/or interesting challenges and topics concerning the technical issues discussed during the work 2014-2018 in WG 29. The WG 29 task was to develop an ISO ACS based on the proposal made by COST TU0901 [15], which already was considered a balanced scheme, since it was based on lessons learned from existing classification schemes and from regulatory requirements in Europe. The development process in TU0901 is described in Ch. 5.3 in [15]. Nevertheless, many technical challenges were awaiting, as foreseen in Section 4.3 in [16].

3.1 Sound insulation descriptors: LF-descriptors (down to 50 Hz) to be applied or not?

One of the stronger points for comments has been about the inclusion or not of the low frequency performance of building constructions in the evaluation of the sound insulation. Based on various publications, see e.g. [37-39], it seems as if for airborne sound, the importance depends on the sound sources considered. For impact sound, there seems to be a consistent international attention to the LF-performance, cf. [20] and [40-42].

Based on the knowledge about existing classification schemes, where LF-descriptors are included in more than half of them, see Section 2.2, LF-performance was also included as default in the draft ISO ACS from the beginning in 2014. However, later some countries made strong arguments against LF-descriptors with one or more reasons, e.g. “not needed”, “high uncertainties”, “against the current national regulations”. Sometimes, it might have been useful with more open discussions on long-term options, when time has come after more experience, considerations on the needs and research, thus reducing fear for the future.

In this "challenge", ISO WG 29 opted for a compromise solution, cf. Tables 6 and 7. Only for the upper classes, where high protection against noise is expected, the LF-limits are default and alternative limits are indicated without low frequencies included.

Table 6 – Airborne sound insulation between dwellings and other rooms. Class limits. From [35].

Table 1 — Airborne sound insulation between dwellings and other rooms — Class limits[a]

	Type of space	Class A dB	Class B dB	Class C dB	Class D dB	Class E dB	Class F dB
1	Between habitable rooms in a dwelling and rooms outside the dwelling in all directions	$D_{nT,50} \geq 58$	$D_{nT,50} \geq 54$	$D_{nT,A} \geq 52$	$D_{nT,A} \geq 48$	$D_{nT,A} \geq 44$	$D_{nT,A} \geq 40$
2	From common stairwells or access areas into habitable rooms in dwellings, where there is an entrance door in the separating wall	$D_{nT,A} \geq 46$	$D_{nT,A} \geq 42$	$D_{nT,A} \geq 38$	$D_{nT,A} \geq 34$	$D_{nT,A} \geq 30$	$D_{nT,A} \geq 26$
3	From premises with noisy activities into habitable rooms in dwellings[b]	$D_{nT,50} \geq 64$	$D_{nT,50} \geq 60$	$D_{nT,A} \geq 58$	$D_{nT,A} \geq 54$	$D_{nT,A} \geq 50$	$D_{nT,A} \geq 46$

[a] Different descriptors are applied to reflect use of different frequency ranges and weightings. Instead of $D_{nT,A}$, $D_{nT,w}$ may be applied if 2 dB is added to the limit value. If $D_{nT,A}$ is applied instead of $D_{nT,50}$, 2 dB should be added to the limit value of $D_{nT,50}$. For comparison between descriptors, see ISO 12354-1.

[b] 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 should be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques, etc. Then, the limits given in Table 4 for service equipment sound can be used as design goals.

Table 7 – Impact sound pressure level in dwellings. Class limits. From [35].

Table 2 — Impact sound pressure level in dwellings — Class limits

	Type of space	Class A dB	Class B dB	Class C dB	Class D dB	Class E dB	Class F dB
1	In habitable rooms in dwellings from other dwellings in all directions	$L'_{nT,w} \leq 46$ and $L'_{nT,50} \leq 50$[a]	$L'_{nT,w} \leq 50$ and $L'_{nT,50} \leq 54$[a]	$L'_{nT,w} \leq 54$	$L'_{nT,w} \leq 58$	$L'_{nT,w} \leq 62$	$L'_{nT,w} \leq 66$
2	In habitable rooms in dwellings from: — common stairwells or access areas — balconies or terraces or bath rooms not belonging to own dwelling[b]	$L'_{nT,w} \leq 50$	$L'_{nT,w} \leq 54$	$L'_{nT,w} \leq 58$	$L'_{nT,w} \leq 62$	$L'_{nT,w} \leq 66$	$L'_{nT,w} \leq 70$
3	In habitable rooms in dwellings from premises with noisy activities[c]	$L'_{nT,w} \leq 40$ and $L'_{nT,50} \leq 44$[a]	$L'_{nT,w} \leq 44$ and $L'_{nT,50} \leq 48$[a]	$L'_{nT,w} \leq 48$	$L'_{nT,w} \leq 52$	$L'_{nT,w} \leq 56$	$L'_{nT,w} \leq 60$

[a] Experience has shown that when applying the low-frequency rating, potentially disturbing high frequency sounds are not rated appropriately, and for this reason, two descriptors are applied in order to account for both hard floor impact sounds as well as low frequency footstep sounds,. The limit values for $L'_{nT,w}$ are 4 dB lower than those specified for $L'_{nT,50}$. For comparison between descriptors, see ISO 12354-2.

[b] Impact sound from small balconies and rooms (area less than 4 m^2) are not included, e.g. toilets and utility rooms.

[c] 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 shall be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques, etc.

3.2 Values assigned to each class, steps between classes and total range

This topic is very important for many countries. In [35], steps between classes for sound insulation and for noise levels are 4 dB (with a few exceptions, when a descriptor changes between classes). The step 4 dB is close to average for sound insulation in existing schemes, corresponds to a substantial step in subjective assessment and allows easy subdivision for special cases. To cover approximately the whole range of most existing classes and regulations in Europe, the proposed classification scheme specifies six classes A-F, the total range is thus in general 20 dB plus an additional denotation NPD (No Performance Determined).

There were only a few comments on steps between classes due to a preference for smaller or bigger steps. The major concern was the position of the total range, since most countries preferred their national regulations to be in Class C, which is impossible to match for all of them due to differences in national regulations. Consequently, some countries consider the proposed ACS rather tolerant compared to their own - and others find it quite demanding with too strict upper classes, which becomes especially clear for countries with none or quite weak regulations. For example considering Brazil and the impact sound insulation criteria, the proposed ISO ACS seems very strict, since class F requires $L'_{\mathrm{nT,w}} \leq 66$ dB, and the regulatory requirement in Brazil is $L'_{\mathrm{nT,w}} \leq 80$ dB, i.e. far below the lowest class. The opposite is the case for e.g. Austria having the impact sound insulation requirement $L'_{\mathrm{nT,w}} \leq 48$ dB, which corresponds approximately to class A (best class) in the ISO proposal. Thus, such countries would not be able to use the ISO proposal directly. – For countries with very weak requirements, a solution might be to keep the higher classer and to extend steps between the lower classes considerably in a national scheme.

3.3 Sound insulation between stairwells and dwellings: How strict?

Criteria for airborne and impact sound insulation between stairwells and dwellings vary between countries and follow different viewpoints, as some countries have stricter criteria towards stairwells and others have lower. In the ISO proposal, it was after some discussions decided to have the same airborne sound insulation (if no doors), but 4 dB weaker criteria for impact sound.

3.4 Stairwells, reverberation time / sound absorption to be included: YES? NO?

Already during TU0901, this topic was surprising, since some countries found it obvious to have limit values, while many others never had thought about it. The compromise in the end of TU0901 was to make optional limits, not being part of the classification. However, later in the ISO WG, more and more countries found limits useful, and limit values ended up as mandatory in the ISO proposal. Then, it was discussed, whether reverberation time or sound absorption limits would be optimal. Since there were mixed preferences, both choices were implemented, as they would both serve the same goal.

3.5 Façade sound insulation: Expressed as max indoor levels or a function of traffic noise?

Sound insulation against traffic noise is dealt with in different ways in different countries, see [14], since some specify minimum façade sound insulation as a function of outdoor traffic noise level (e.g. FR, DE, AT), and others (e.g. the Nordic countries) use max indoor traffic noise levels, and some countries use fixed limit values for the building envelope sound insulation. Thus again, there were many discussions, and compromises had to be made, also about descriptors. The compromise became having a simple equation for the minimum façade sound insulation ($D_{\mathrm{n}T\mathrm{,A,tr}} \geq L_{\mathrm{den}} - \mathrm{XX}$), see Table 3 in [35] and allow other weightings for other sources, if more optimal. There was also an additional request for indication of sound insulation as an absolute value (not just a class), but no decision made.

3.6 Traffic noise on outdoor areas?

Some countries have outdoor traffic noise included in their national acoustic classification schemes, either mandatory or as an option. The topic was discussed briefly, but although relevant, WG 29 decided not to include such outdoor conditions in the classification.

3.7 Service equipment noise: How many different limits? Which standards?

When discussing how to define service equipment noise limits, it seemed as if all countries had made their own national decisions on descriptors (equivalent, max or other ways), which sources to include and how to group sources. Also, there were many strong viewpoints on allowing only ISO 16032 [8] as measurement method, while other countries insisted on also keeping survey method in ISO 10052 [7]. The compromise was to allow both methods, but in case of dispute to use ISO 16032 as the reference method. In Clause 3 of [35] various sources were included in the definition. For other details, see [35].

3.8 Sound insulation internally in dwellings?

In most of the existing acoustic classification schemes, limits for airborne and impact sound insulation are included in the higher classes, cf. [16], although optional in some of the schemes. There were discussions in WG 29 more times due to the relevance and formal comments during ballots. However, since some countries have mixed experience, the compromise was to skip the issue in the ISO proposal and leave further discussions for a future update.

3.9 Verification procedure for compliance with class criteria

The quality of the verification process is important, since the results provide the proof for the builder and the users. The ISO proposal includes general guidelines in Clause 6 and details in Annex A. Two procedures are defined:

A: Verification by calculations, visual inspections and field measurements
B: Verification by field measurements only

A big question is who is entitled to do the different tasks in a verification process? Can any self-declared acoustic consultant do the calculations at the design stage and select the spaces (5% or 10%) for measurements? Who is entitled to make the acoustic measurements? Any requirements for the companies/consultants making the measurements? Since all experts want qualified results, there were many discussions in WG 29 due to the relevance and the formal comments during ballots. A restrictive approach could be that all calculations and sampling decisions shall be made by recognized/certified acoustic experts and all measurements made by certified persons/organizations having a quality system implemented. However, the experience from practice is that very detailed verification processes won't be followed in practice, because they are too expensive. In this "challenge", most of the experts in WG 29 opted for keeping the verification simpler to make it happen rather than describing a very precise procedure not happening. Thus, the WG 29 compromise is a relatively open approach. The general procedure for verification is described in Clause 6 in [35]:

"Theoretical evaluations, experiences with similar building designs as well as visual inspections of critical constructions in the building during production have proved to be valuable as a part of a verification procedure. In cases with several types of constructions, considerable variations in floor plans or use of rooms, it can be necessary to increase the number of measurements. Hence, the number of sample measurements in the completed building should be chosen to fit to the actual conditions. Annex A may be followed in detail or adapted somewhat if needed to reflect special conditions in the building or for other relevant reasons, as long as such changes are not in conflict with the general requirement. It is advised to agree on a complete verification procedure at an early stage of a building project.

3.8 Class designation for dwelling/building – Why lowest class decisive to final class?

During the ballots there were detailed suggestions for choosing a sort of qualified average instead of just choosing the class corresponding to the lowest results. However, the classification is a tool for builders and users to be informed about the acoustic quality of a dwelling/building. Just as in any other technical field (i.e. building stability), choosing the lowest class is choosing to work with the maximum safety margin, and the verification procedure allows on beforehand reasonable deviations due to measurement uncertainties. The quality shall be equal to or above the specification. That is what the end user needs to know.

4. THE ISO/WI 19488 STANDARDIZATION PROCESS & CHALLENGES

Parts of the history of ISO/WI 19488, including the preceding COST Action TU0901 [10] is explained in the Introduction. ISO/WI 19488 was approved by ISO/TC 43/SC 2 “Building Acoustics” in 2014 and WG29 established the same year. WG 29 had its first formal meeting in January 2015, and until end of 2018 seven WG meetings were held, where contents of the standard and ballot comments have been discussed. In WG 29, there are 55 experts from 25 countries, which - if compared to any other WG within SC2 shows a high interest (although for mixed reasons). ISO/TC 43/SC 2 Building Acoustics has 30 P-members and 16 O-members [46]. Since the start of WG 29, there have been four ballots (CD, 2nd CD, DIS, FDIS) and a large number of comments have been received, e.g. for the ISO/DIS 19488 more than 100. Responding, integrating and achieving consensus or compromises have been time consuming and often difficult or impossible, since some comments were contradicting each other, sometimes even from the same country in the same ballot, e.g. Germany requesting R'_{w} and $D_{nT,w}$ as sound insulation descriptor, probably also a sign of national chaos, see e.g. [45], explaining various competing national systems. However, for many topics, cf. examples in Section 3, there were fruitful international discussions, leading to new insights and considerations, although it will take time to optimize existing national choices and traditions.

In addition to the technical challenges, there were challenges due to various fears for reactions to changes, which might lead to confusing scenarios for legislators and builders in countries, where acoustic classification schemes or regulations already exist: What would the implications be for national legislation? What could happen, if high-end classes become available? Some stakeholders don’t want users to ask for better acoustic performance. And what would it mean to disputes? − The ISO/DIS was approved in December 2017, although several critical comments were identical from three countries with no or non-active WG members, indicating “external” influence, seemingly from specific manufacturers. A negative vote also appeared from a few countries, where the national committee seemed unaware why. It is of course the right of any country to vote according to the belief and change position throughout the total process, which actually happened both ways. But some questions appear, e.g. when there suddenly for the FDIS is a negative vote from a previously totally inactive country being O-member and having had no comments before. It also raises a question about the rules for approval. The ISO voting criteria are (abstain does not count): (a) P-members: Approved ≥ 66.66%; (b) All P- & O-members: Disapproved ≤ 25%. Since the ISO/FDIS voting in October 2018 did not meet the ISO criteria for approval, and an ISO standard or another ISO deliverable is wanted, the options were discussed, see Section 6. In the long run, the only way to overcome the fear of conflict with national regulations is to understand the role of ISO Standards and other deliverables, e.g. Technical Specifications (TS). The following information has been extracted from ISO´s website [46].

Role of ISO Standards: *“A Standard is a document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards make trade between countries easier and fairer because the same specifications are adopted for use in different countries as national or regional standards. Besides, standards are an effective and commonly used support to national technical regulations.*

Standards are voluntary agreements, developed within an open process that gives all stakeholders, including consumers, the opportunity to express their views and have those views considered. This contributes to their fairness and market relevance, and promotes confidence in their use. The important distinction between standards and legislation is that standards are voluntary, whereas legislation is mandatory. When regulatory authorities use standards as a basis for legislation, only then do they become mandatory, and then only within the jurisdiction covered by the legislation. Regulatory authorities decide themselves whether to use Standards to support their technical regulations or not. In Europe standards are used to support pan-European legislation and are mandatory only when referenced in specific EU Directives, but otherwise the decision on their use remains voluntary.

Under the World Trade Organization (WTO) rules, governments are required to base their national regulations on standards produced by organizations like ISO, as much as possible. Partly because of these rules, and also because of the general globalization of trade, national and regional standards bodies are either adopting or otherwise using International Standards, where possible."

Role of Technical Specifications: *"A Technical Specification addresses work still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on an International Standard. A Technical Specification is published for immediate use, but it also provides a means to obtain feedback. The aim is that it will eventually be transformed and republished as an International Standard."*

5. CURRENT STATUS OF ISO/NP TS 19488

The current status is, see above, that that the ISO/FDIS 19488 was disapproved in October 2018. Following the advice from ISO and of many WG 29 experts, it was decided to propose publication of an ISO Technical Specification (TS) instead, cf. the above description of TS. At the ISO/TC 43/SC 2 meeting in Matsue/Japan in Nov. 2018, SC 2 decided, cf. Resolution No. 10:

- to reinstate the project as a TS with the unchanged text of the FDIS document;
- to start a 8 weeks NP-ballot on ISO/NP TS 19488, *Acoustics — Acoustic classification of dwellings;*
- that after possible approval of the NWI, the DTS ballot shall be started directly on the unchanged document.

The 8 weeks NP-ballot was made among SC 2 member countries and ISO/NP TS 19488 approved on 11 March 2019, and thus a DTS ballot can start as soon as the DTS document is ready. According to the SC 2 decision, the technical contents will remain unchanged. However, it may be wise to reword the Scope and Introduction before the DTS ballot to fit better the purpose of the TS.

6. CONSENSUS FOR ISO/DTS 19488?

During the work in COST TU0901 and ISO/TC 43/SC 2/WG 29, some countries started preparing a national acoustic classification scheme, for example Turkey and Brazil. Especially these two countries have expressed strong wishes for an international document as a "background reference" for the national scheme, see e.g. mail text from the Brazilian WG 29 members, who could not attend the meeting in Japan Nov. 2018:

"As Brazil representatives, we support the publication of the contents of ISO/FDIS 19488 proposal either as an ISO standard, TS or TR. The implementation of an international Acoustic Classification Scheme will foster many countries - such as Brazil - to develop their own ACS, according to each country's reality, but following common guidelines. It is believed that it can help to increase the Brazilian construction market awareness on better building acoustic performance and users' satisfaction."

In Turkey, they made what is almost a MIRACLE, since – based on hard project work and inspiration from participation in COST Action TU0901 – they prepared acoustic regulations, acoustic quality classes, and guidelines for various types of buildings, including enforcement, cf. [33]. Turkey did not have acoustic regulations before, and in the actual situation, it was seemingly easier, although still challenging, to prepare a new set of regulations than a small revision is in many other countries! The regulations were published in 2017 and put into force in 2018.

In addition, other countries are considering national classification schemes or future revisions of regulations based on the international interchange of experience in WG 29, and the authors of this paper recommends CONSENSUS, i.e. approval of the ISO/DTS 19488, since:

- it is believed that a joint international document will increase awareness on acoustics among authorities, builders and building industry and provide a common ground for collecting experiences for future discussions, research and revisions.
- in the end, acoustic classification and regulations shall serve the needs of people, who need privacy in their homes during various activities.
- information about acoustic quality of dwellings is useful both for new dwellings and existing dwellings, in analogy with energy labelling of dwellings. In many countries, a major part of the housing stock has been built before there were any acoustic regulations, and awareness and upgrading needed.

ACKNOWLEDGMENTS

The authors want to thank all ISO/TC 43/SC 2/WG 29 members for fruitful discussions and national committees for input to the ISO ACS proposal ISO/WI 19488, subject of this paper.

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