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Sound insulation between dwellings – Comparison of national requirements in Europe and interaction with acoustic classification schemes

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ABSTRACT

Most European countries specify limit values for airborne and impact sound insulation in housing. The requirements are expressed by descriptors defined in ISO standards implemented also as European and national standards. A comparative study investigating the regulatory requirements for airborne and impact sound insulation between dwellings in 35 countries in Europe has been carried out. The comparison shows considerable differences in terms of descriptors, frequency ranges and level of requirements.
Sufficient sound insulation between dwellings is important to protect against noise from neighbours and to provide privacy and possibilities for activities without causing annoyance. In addition to acoustic regulations, more than one-third of the countries have developed acoustic classification schemes with classes reflecting different levels of acoustical comfort/protection. In some countries regulations point to a specific acoustic class, but are in other countries independent. The interactions will be described. All schemes have minimum two classes above regulations, thus enabling specification of higher acoustic quality than regulations, but typically only one class below regulations, implying that major parts of older housing cannot be classified. It is concluded that acoustic classification schemes should preferably include classes covering all existing housing, independent from construction year, thus allowing acoustic labelling in analogy to energy labelling.

Keywords: Sound insulation; Dwellings; Acoustic regulations, Classification

1. INTRODUCTION

Findings from national social surveys in several European countries have shown that noise from neighbours' activities annoy many people living in multifamily housing. Results from several countries have been compiled and published in 2009, see [1]. However, while health implications of traffic noise have been quite thoroughly investigated by WHO and the European Environmental Agency (EEA) for decades and several reports published, neighbour noise is only addressed in a few studies like e.g. WHO LARES [2], where e.g. sleep disturbance from neighbour noise is reported as almost the same as for traffic, while other noise sources are far below. References to other surveys newer than those included in [1] are found in e.g. [3]. The far most extensive national studies have been made in UK, see [4,5], with very detailed interviews and reporting. According to these surveys, adverse implications of neighbour noise on home life seem to be the same as for traffic noise, i.e. sleep disturbances, use of rooms, quiet activities (reading, writing, resting), having a conversation, listening to music/radio/TV. The EU Environmental Noise Directive (END), [6], requires national mapping of external noise and action plans every fifth year, but there seems to be no European policies concerning sound insulation between dwellings.

Regulatory sound insulation requirements for dwellings exist in more than 30 countries in Europe. In some countries, requirements have existed since the 1950s or even before, while in others, regulations came later or do not yet exist. Comparative studies of descriptors and regulations in 2008 for 24 countries in Europe are described in detail in [7,8] with result updates and extensions to 35 countries in 2013 in [9]. Acoustic classification schemes are described in [10,11]. Findings show that descriptors, requirements and classification schemes in Europe represent a high degree of diversity. Updates to April 2019 will be included in this paper as well as interaction between acoustic regulations and classification schemes. Since regulations apply to new housing, and a major part of the European housing stock has been built before any national acoustic regulations existed, a tool for description of acoustic quality of old housing is most often missing, if national acoustic classes do not exist or relevant classes are missing.

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2. METHODOLOGY

The methodology for collection of data for national acoustic regulations follows the principles outlined in [7], i.e. the analysis is primarily based on direct access to the documents describing the requirements. Such documents could be building regulations or publications referred to in the building regulations. In some cases, typically for countries with ‘‘difficult” languages, documents were accessed mainly through contact persons. As indicated in [10], structures of legislation differ widely, including contents, size and number of relevant documents. In some countries, the documents specifying the requirements are available at the web, but in many countries, they must be purchased from the standardization organizations. The work builds on experience and contacts from previous surveys. The major challenges were finding the right documents and sections and not least the language issue. Concerning the acoustic classification schemes, the methodology and challenges were similar.

3. REQUIREMENTS FOR SOUND INSULATION BETWEEN DWELLINGS

In this Section are found the results of a comparative study of sound insulation descriptors and requirements in 35 countries in Europe. Acoustic regulations are most often for new-build only, and the limits described in this Section apply to new housing. Detailed requirements and conditions are found in the building regulations or in the documents referred to in the regulations.

The original main study for 24 countries is from 2008 and the findings described in [7-8]. In 2011-2013, Bulgaria, Croatia, Cyprus, Greece, Luxembourg, Macedonia FYR, Malta, Romania, Scotland, Serbia and Turkey were added as new countries, and requirements updated for the Czech Republic, Iceland and Portugal due to revision of the building regulations. The findings from the updated and extended study to 2013 for 35 countries are described in [9] published in 2014, but the background, explanations and most details are found in [7-8]. Out of the 35 countries included in [9], five countries (Cyprus, Luxembourg, Macedonia FYR, Malta, Turkey) had no requirements.

For the current study, regulations have been updated with new/revised regulations for Poland (2015), Sweden (2015), Germany (2016), Finland (2018), Turkey (2018) and a mistake in the regulations for Romania corrected. For the updated list of 35 countries, four of the 35 countries (Cyprus, Luxembourg, Macedonia FYR, Malta) have no requirements.

The acoustic descriptors applied in building regulations are defined in the ISO standards [12,13] for measurement and rating, although some countries apply additional national variants or conditions. Within building acoustics, ISO standards are usually implemented as European (EN) standards and national standards.

Sound insulation descriptors applied in national sound insulation requirements for dwellings are shown in Table 1 for 31 countries in Europe (since 4 of the 35 countries do not have acoustic regulations). Based on the results presented in the Table 1, the diversity of descriptors applied in Europe is obvious. Sound insulation descriptors are defined in ISO 717 [12], which unfortunately allows a high variety of descriptors. Detailed, comparative studies of sound insulation descriptors for regulations and classification schemes (housing) are described in [7,8]. Efforts were made and are still made to promote harmonization of descriptors in Europe, see e.g. [9,14].

The main requirements for airborne and impact sound insulation in 35 countries are presented in Tables 2 and 3. The results clearly indicate the diversity in Europe. The comparison reveals significant discrepancies in descriptors and requirements for dwellings. For both airborne and impact sound insulation, several descriptors are applied in Europe, see Tables 1-3.

Table 1 – Sound insulation descriptors applied for regulatory requirements between dwellings in 31 countries in Europe. Status April 2019.

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	$L'_{nT,w} + C_{I,50\text{-}2500}$
1	$D_{nT,w} + C_{50\text{-}3150}$	1	L'_w
1	$D_{nT,A}$ ($\approx D_{nT,w} + C_{100\text{-}5000}$)	?	Variants
1	$D_{nT,w} + C_{tr}$	?	Recommendations
?	Variants	?	Special rules
?	Recommendations		
?	Special rules		

Table 2 - Airborne sound insulation between dwellings. Main requirements in 35 European countries [1]

Requirements [1] Status April 2019		Multi-storey housing	Comments
Country	**Descriptor [2]**	Req. [dB]	See notes below table
Austria	$D_{nT,w}$	≥ 55	(3)
Belgium	$D_{nT,w}$	≥ 54	(3)
Bulgaria	R'_w	≥ 53	(5)
Croatia	R'_w	≥ 52	
Cyprus	N/A	N/A	(8)
Czech Rep.	R'_w	≥ 53	(3)
Denmark	R'_w	≥ 55	
England & Wales	$D_{nT,w} + C_{tr}$	≥ 45	(10)
Estonia	R'_w	≥ 55	
Finland	$D_{nT,w}$	≥ 55	
France	$D_{nT,w} + C$	≥ 53	
Germany	R'_w	≥ 53	(3),(5)
Greece	R'_w	≥ (50)	(8),(9)
Hungary	$R'_w + C$	≥ 51	(3)
Iceland	R'_w	≥ 55	(4)
Ireland	$D_{nT,w}$	≥ 53	(5)
Italy	R'_w	≥ 50	(6)
Latvia	R'_w	≥ 54	
Lithuania	$D_{nT,w}$ or R'_w	≥ 55	(4)
Luxembourg	N/A	N/A	(8)
Macedonia FYR	N/A	N/A	(8)
Malta	N/A	N/A	(8)
Netherlands	$R'_w + C$	≥ 52	
Norway	R'_w	≥ 55	(4)
Poland	$R'_w + C$	≥ 50	(5)
Portugal	$D_{nT,w}$	≥ 50	
Romania	R'_w	≥ 51	
Scotland	$D_{nT,w}$	≥ 56	(10)
Serbia	R'_w	≥ 52	
Slovakia	R'_w or $D_{nT,w}$	≥ 53	(3)
Slovenia	R'_w	≥ 52	
Spain	$D_{nT,A} \approx D_{nT,w}+C_{100-5000}$	≥ 50	
Sweden	$D_{nT,w} + C_{50-3150}$	≥ 52	
Switzerland	$D_{nT,w} + C$	≥ 52	(3),(7)
Turkey	$D_{nT,w} + C$	≥ 52	

Notes

(1) Overview information only. Detailed requirements and conditions are found in the building codes.
(2) No generally applicable conversion between the different descriptors exists, as the relations depend on characteristics of rooms and constructions. Exact conversion can only be made in specific cases.
(3) In AT, BE, CZ, DE, HU, SK, CH, 3-9 dB stricter limits apply for row housing.
(4) Use of $R'_w + C_{50-5000}$ recommended. If applied, the limit value may be reduced, see regulations.
(5) Horizontal, requirement for vertical is 1 dB higher (Bulgaria, Germany, Poland) / lower (Ireland).
(6) The indicated limit values are for private housing. Requirements for public dwellings are 3 dB stricter (Class II in UNI 11367:2010).
(7) Flats for rent. If owned by occupants, limits are 3 dB stricter.
(8) No regulatory requirements. In Luxembourg, most often limits from Belgium or other neighbouring countries are applied, dependant on the consultant.
(9) Proposed requirements, not yet mandatory.
(10) Although England & Wales and Scotland are parts of UK, they are listed as separate countries due to different requirements.

Table 3 - Impact sound insulation between dwellings. Main requirements in 35 European countries [1]

Requirements [1] Status April 2019		Multi-storey housing	Comments
Country	**Descriptor [2]**	Req. [dB]	See notes below table
Austria	$L'_{nT,w}$	≤ 48	(3)
Belgium	$L'_{nT,w}$	≤ 58	(3),(5)
Bulgaria	$L'_{n,w}$	≤ 53	
Croatia	L'_w	≤ 68	(6)
Cyprus	N/A	N/A	(10)
Czech Rep.	$L'_{n,w}$	≤ 55	(3)
Denmark	$L'_{n,w}$	≤ 53	
England &Wales	$L'_{nT,w}$	≤ 62	(12)
Estonia	$L'_{n,w}$	≤ 53	
Finland	$L'_{n,w} + C_{I,50-2500}$	≤ 53	
France	$L'_{nT,w}$	≤ 58	
Germany	$L'_{n,w}$	≤ 50	(3)
Greece	$L'_{n,w}$	≤ (60)	(10),(11)
Hungary	$L'_{n,w}$	≤ 55	(3)
Iceland	$L'_{n,w}$	≤ 53	(4)
Ireland	$L'_{nT,w}$	≤ 62	
Italy	$L'_{n,w}$	≤ 63	(8)
Latvia	$L'_{n,w}$	≤ 54	
Lithuania	$L'_{n,w}$	≤ 53	(4)
Luxembourg	N/A	N/A	(10)
Macedonia FYR	N/A	N/A	(10)
Malta	N/A	N/A	(10)
Netherlands	$L'_{nT,w} + C_I$	≤ 54	
Norway	$L'_{n,w}$	≤ 53	(4)
Poland	$L'_{n,w}$	≤ 55	
Portugal	$L'_{nT,w}$	≤ 60	
Romania	$L'_{n,w}$	≤ 62	
Scotland	$L'_{nT,w}$	≤ 56	(12)
Serbia	$L'_{n,w}$	≤ 68	
Slovakia	$L'_{n,w}$ or $L'_{nT,w}$	≤ 55	(3)
Slovenia	$L'_{n,w}$	≤ 58	
Spain	$L'_{nT,w}$	≤ 65	
Sweden	$L'_{nT,w} + C_{I,50-2500}$	≤ 56	(7)
Switzerland	$L'_{nT,w} + C_I$	≤ 53	(3),(9)
Turkey	$L'_{nT,w}$	≤ 54	

Notes

(1) Overview information only. Detailed requirements and conditions are found in the building codes.
(2) No generally applicable conversion between the different descriptors exists, as the relations depend on characteristics of rooms and constructions. Exact conversion can only be made in specific cases.
(3) In AT, BE, CZ, DE, HU, SK, CH, 3-10 dB stricter limits apply for row housing.
(4) Recommended that the same criteria are fulfilled by $L'_{n,w} + C_{I,50-2500}$.
(5) From “non-bedrooms” outside the dwelling to a bedroom ≤ 54 dB is required.
(6) L'_w not defined in ISO 717-2. It is assumed to be $L'_{n,w}$.
(7) The same criteria shall also be fulfilled by $L'_{n,w}$.
(8) The indicated limit values are for private housing. Requirements for public dwellings are 5 dB stricter (Class II in UNI 11367:2010).
(9) Flats for rent. If owned by occupants, limits are 3 dB stricter.
(10) No regulatory requirements. In Luxembourg, most often limits from Belgium or other neighbouring countries are applied, dependant on the consultant.
(11) Proposed requirements, not yet mandatory.
(12) Although England & Wales and Scotland are parts of UK, they are listed as separate countries due to different requirements.

In order to facilitate a comparison between countries, all requirements have been converted into estimated equivalent values of $D_{nT,w}$ and $L'_{nT,w}$ based on assumptions about rooms and construction types, see [7]. In case of the equivalent $D_{nT,w}$ being an interval, the average value has been used. The equivalent values are estimates only, as exact conversion is not possible. A graphical presentation of the requirements for airborne and impact sound insulation are presented in Figures 1 and 2, and it is seen that especially the requirements for impact sound differ considerably across Europe, since the range for airborne is about 7 dB, and for impact about 18 dB.

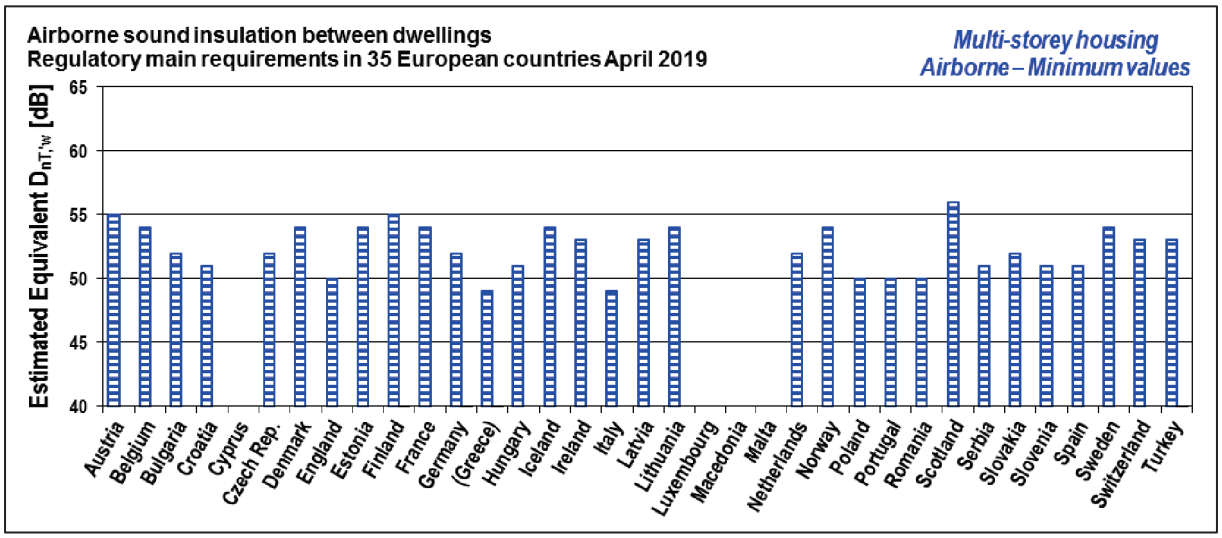

Figure 1 – Overview of airborne sound insulation requirements between dwellings. Status April 2019. Graphical presentation of estimated equivalent values of $D_{nT,w}$.
Note: The equivalent values are estimates only, as exact conversion is not possible.

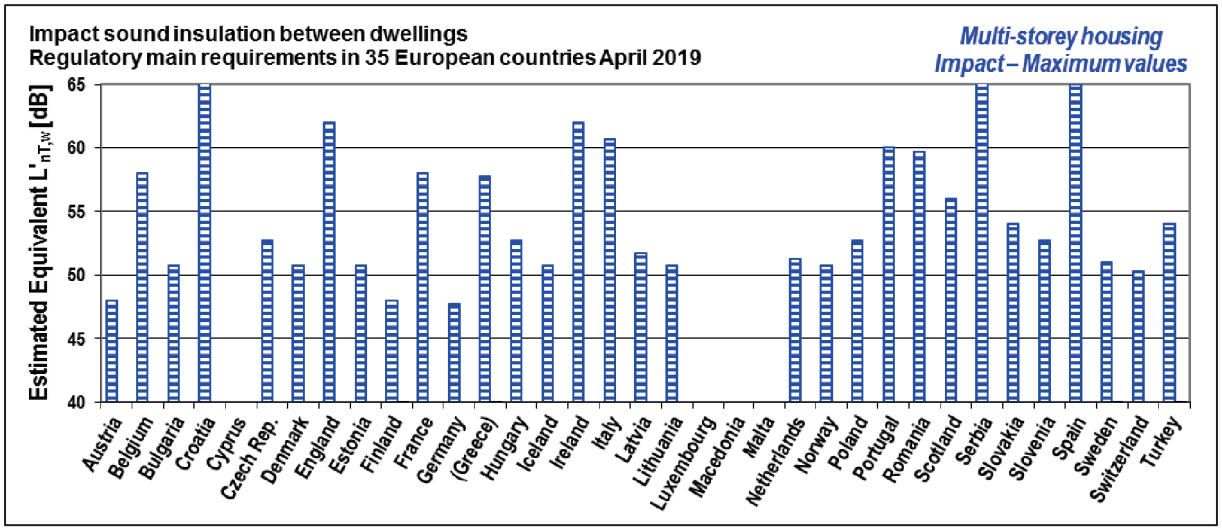

Figure 2 – Overview of impact sound insulation requirements between dwellings. Status April 2019. Graphical presentation of estimated equivalent values of $L'_{nT,w}$.
Note: The equivalent values are estimates only, as exact conversion is not possible.

4. ACOUSTIC CLASSIFICATION SCHEMES IN EUROPE − OVERVIEW

Acoustic classification schemes (ACS) define a number of quality classes reflecting different levels of acoustic comfort and protection, see illustration in Table 4. The ACS are national and very different due to lack of coordination between countries. An overview of existing national acoustic classification schemes in Europe for dwellings, [15-28], is found in Table 5. For each scheme listed, the class denotations, number of classes and the relation to the national building code are indicated. Information about the background for an international proposal is found in [29], and the ISO/FDIS in [30]. Table 5 also includes number of classes below and above the national regulations.

Table 4 – Range of acoustic quality classes using various, partly FICTIVE ranges and denotations

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

Table 5 – European schemes for acoustic classification of dwellings, [15-28], relation to building regulations and class information. ISO/FDIS 19488 (2018), [29], included for comparison.

Acoustic classification of dwellings - Schemes in Europe and relation to building codes – Status April 2019								
Coun-try	Year of publication	CS Reference (latest version)	Class denotations(1)	BR link to CS	BR ref. to CS & 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	1
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)	A / B / C / D	–	N/A (See note(4))	4	2	1
LT	2003	STR 2.01.07 (2003)	A / B / C / D / E	+	Class C	5	2	2+npd
LV	2011/2015	LBN 016-15 (2015)	A / B / C / D	+	Class C	4	2	~ 0
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	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	AQ-4 / AQ-3 / AQ-2 / AQ-1 / AQ-0	–	N/A (BR ~ Class AQ-0)	5	4	0
TR	2017	Noise Protection and sound insulation in Buildings(6)	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(5))	6+npd	N/A	N/A

Abbreviations: BR = Building Regulations (regulatory requirements); CS = 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 (2015) does not include class C criteria, but refers to values in the BR as class C.

(5) Original proposal prepared by COST TU0901 in 2013. ISO/WI 19488 from 2014, ISO/FDIS in Aug. 2018.

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

The variety of airborne and impact sound insulation descriptors applied in the classification schemes for housing in Table 5 are found in [11], Tables 5 and 6 (although Latvia is missing due to the author's unawareness of the LV acoustic classes). Limit values, status 2012, are found in [31].

When considering the information in Table 5, some schemes may appear similar, e.g. NL and IT, but they are very different, since sound insulation descriptors, class intervals, ranges and position of quality classes vary between the countries. Several differences between the national acoustic classification schemes are found, see details described in e.g. [3,9,11,14]. From [11], it is seen that the quite new Polish ACS [27] in the two upper classes applies the descriptor $R'_w + C_{tr}$ for sound insulation between dwellings, i.e. a similar approach as for regulations in England and Wales, but not applied by any other country in an acoustic classification scheme.

It is obvious that acoustic classification could be relevant for existing housing before renovation by using lower classes suitable for existing housing. From Table 5 it is seen that four (FI, IS, NO, SE) of the Nordic countries and Italy have one quality class below regulations, Lithuania and the Netherlands have two classes, Austria and Germany (DEGA 103) 1+npd. DK and TR have three classes below regulations, implying a much higher chance of classifying older housing. Germany (VDI 4100) has none, thus following the original idea of acoustic classes to be only/mainly for specifying better acoustic conditions than regulations. To sum up briefly, the existing acoustic classification schemes do in general not include acoustic classes fitting major parts of the existing housing stock. In [32], which includes mapping of the Danish housing stock, i.e. number of dwellings according to construction year, constructions and estimated sound insulation, it was suggested to extend the DS 490:2007 with two lower classes E and F suitable for older housing, see also [10] and Figure 1 in [33]. An extension like that could pave the road for a future acoustic labelling in a similar way as for the mandatory energy labelling used also for existing buildings, including housing and many other building categories.

Comparing the data from the classification schemes in Europe, see Table 5, detailed class criteria in [15-28] and descriptor tables in [11], 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 (~ 6 to 22 dB for airborne, ~ 6 to 30 dB for impact) and position.
- Relation to regulatory requirements.

Quality class intervals and actual limit values (not just descriptors) are found in [31], status 2012. Use of low-frequency descriptors are dealt with in [11].

5. INTERACTION ACOUSTIC REGULATIONS AND CLASSIFICATION SCHEMES

From Table 5 it is seen that in six countries (DK, IS, NO, LT, LV, TR), the BR refers to Class C in the national ACS as the acoustic regulations. The same principle was applied in SE until 2015, where the regulatory limit values instead were included in the BR, and the Class C columns in [19] included no longer limit values, but defined the BR limit values as Class C. Thus, there is still a dependency between BR and ACS in SE, although the other way. In the remaining six countries, the interactions are more mixed, although in five of these countries, the BR limit values correspond *approximately* to a class, and in AT, they are the same as in Class C. Note: None of the acoustic classes C are the same.

As examples on interaction, the following explanations apply to the five Nordic countries:

DK: BR [34] refers to Class C in [15], which includes only housing.
FI: No interaction between BR [35] and ACS [16]
IS: BR [36] refers to Class C in [17] for all buildings.
NO: BR [37] refers to Class C in [18] for all buildings.
SE: The ACS [19] has no limit values for Class C, which is defined as the actual regulations [38].

Considering the sound insulation requirements in more than 30 countries in Europe and the whole collection of national acoustic classification schemes in 13 countries in Europe, the lack of harmonization is regrettable for several reasons, one of them being difficulties with exchanging construction solutions for various sound insulation performance levels.

An important topic is also the whole structure of a building codes and related documents. In many countries, it is very difficult to get a complete overview of acoustic regulations, guidelines and recommendations due to a complex variety of documents published by authorities, institutes, councils, standardization organizations and various other organizations and with no joint document linking those documents together. For many countries, it could be recommended to simplify considerably, e.g. by having – as in Norway [18] – the acoustic part of the building code referring to a specific acoustic class in a classification scheme, which should include all building applications and thus be the starting point for the acoustic design of any building.

Some countries have separate, stricter regulatory limit values for row housing than for multi-storey housing, see notes in tables 2-3. Correspondingly, one of the German classification schemes [23] has a separate set of criteria for these two housing types. An untapped potential seems to be available, if applying an ACS in e.g. the following way:

- Acoustic regulations for new row housing: Class B
- Acoustic regulations for new multi-storey housing: Class C
- Acoustic regulations for renovated housing, e.g. Class D
- The lower acoustic classes for older housing for description of the acoustic quality as information only or as basis for decision about renovation.
- Acoustic classes could also be applied as basis for acoustic evaluation in green building certification.
- Acoustic labelling according to the same principles as energy-labelling

6. CONCLUSIONS & RECOMMENDATIONS

Findings from the comparative studies show as in previous studies considerable differences in descriptors and limit values. It's also found that the structure of documents related to the regulations often is very complex. Language issues often make it difficult to find the right paragraphs, but even without language problems, it's often a challenge.

It would be preferable to have a more harmonized acoustic classification scheme with classes appropriate for both new and older buildings – and even as a tool for green building certification. A system with the building regulations pointing to one document with all acoustic limit values for various buildings in separate sections, e.g. like in [18]. An overview of various acoustic classification schemes, including other buildings than housing is found in [39].

Since acoustic conditions is a hidden quality, labelling would be useful to provide 'visible' information about the acoustic quality concerning protection against neighbour noise and at the same time indication of own possibilities for activities without disturbing neighbours.

At last, it must be noted that the limit values included in this paper should not be applied directly, but the original documents consulted, since details and conditions are found in these documents.

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