Sound insulation requirements in multi-storey housing – A health issue or just comfort?

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Introduction

In Europe, sound insulation requirements for dwellings are included in building regulations in more than 30 countries. In several countries, requirements existed since the 1950s or before, while in some other countries, acoustic regulations came later or don't exist. Also, it was realized that complying with regulations does not guarantee satisfactory acoustic conditions for occupants, and in the 1990s, some countries developed acoustic classification schemes (ACS) with quality classes reflecting higher acoustic protection and comfort. Later, more countries developed national ACS, some also having lower classes for older housing with lower limits than regulations. Nevertheless, seemingly most countries miss overview of compliance with regulations and issuing of quality class certificates is modest. – During the last few years, the fight against climate changes have led to focus on lightweight building materials, which unfortunately have insufficient sound insulation, unless much thicker constructions are applied and/or product/construction development has taken place. This reality has led to a situation, where parts of the building industry request considerably lower sound insulation requirements – without knowing the history of regulations or how many people suffer from neighbour noise in housing. The paper will explain potential health effects of neighbour noise and recommend mandatory acoustic labelling aiming at open access to acoustic quality.

Sound insulation requirements in building regulations: Why?

Most countries in Europe have acoustic regulations for various types of buildings, including housing and educational buildings. This paper deals with airborne and impact sound insulation between dwellings in multi-storey housing. Requirements for 35 countries are found in [1] and information about acoustic classification schemes and sound insulation descriptors in 14 countries in Europe are described in [2]. Both requirements and acoustic classes relate to peoples' everyday life, because neighbour noise often is a significant problem in multi-storey housing (MSH), cf. [3] and [4], both based on a social media analysis of over 700 comments to two newspaper articles about acoustic labelling and neighbour noise.

The increasing building costs in general and the more recent challenge to comply with regulations, even if the building industry has limited experience with use of lightweight materials to be applied, when fighting climate changes, has led to strong discussions on where to reduce costs. Since stability of constructions and fire protection must be complied with, reducing other performances are considered. Consequently, acoustic requirements have got attention for more reasons, one of them being uncertainty about how to design with new materials (and fulfil requirements) and another one the fact that parts of the building industry consider sound insulation as luxury and not something needed for wellbeing or health.

However, typical reasons for acoustic regulations are *health* related. For example, in the current DIN 4109-1 [5], the introduction refers to health protection of occupants in housing, including also confidentiality during normal speech and protection against unreasonable disturbance. It is also stated that it *cannot* be expected that noise from outside or from neighbouring rooms will no longer be perceived or found annoying, even if the requirements laid down in the standard are met. There is a long story behind the DIN 4109 series of standards and the importance for building acoustics in Germany, see [6].

The background and development until 1994 of acoustic regulations in Denmark for housing is described in [7] and current regulations indicated in e.g. [8]. Again, as in Germany, the word health is predominant in the beginning of the regulations chapter. The situation is probably similar in many other countries.

Concerning disturbing neighbour noises, results from research projects agree that impact sound (footsteps) annoy most people, see e.g. [9], [10], [11]. Several disturbing neighbour noises are listed in [12], which also – based on a representative national survey – reports examples of potential adverse health effects of neighbour noise in multi-story housing. A strong association is found between self-reported neighbour noise annoyance and perceived stress, poor mental health, fatigue, sleeping problems, sleep quality (getting enough sleep to feel rested), see [12].

Acoustic classification of housing: Schemes in Europe and subjective descriptions of classes

Acoustic classification schemes (ACS) for dwellings exist in at least 14 countries in Europe. In Germany, there are two schemes, one published by VDI, the other by DEGA. An overview of the schemes is found in Table 1 (from [2]). The table also includes numbers of acoustic classes below and above the national regulations. Three schemes have no classes below regulations, implying that old housing not complying with current regulations cannot be classified.

In Table 2 is found an overview of classes in the current Danish classification scheme, DS 490:2018 [13], which has six classes A-F covering the Danish housing stock. The table provides simple explanations of the intended application of classes for new and old housing, see [14]. It also indicates the occupants' expected evaluation of the sound insulation.

Table 1: European schemes for acoustic classification (ACS) of dwellings, relation to building regulations (BR) and class information. ISO/TS 19488 (2021), included for comparison. Table from [2]. The notes and references [5-20] belonging to the table are found in [2].
Note: The table is not up-to-date, since at least three publications have been revised (FI, SE, DEGA), but the overall meaning is unchanged.

Acoustic classification of dwellings - Schemes in Europe and relation to building regulations – Status May 2022								
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	1997–2019 (5 versions)	NS 8175 (2019) (9)	A / B / C / D	+ (9)	Class C (9)	4	~ 2	~ 1
SE	1996–2015 (4 versions)	SS 25267 (2015)	A / B / C (2) / D	–	N/A (See note (2))	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) (3)	III / II / I	–	N/A (BR ~ Class I (2))	3	3	~ 0
DEGA	2009 / 2018	DEGA Empfehlung 103 (2018) (4)	A*/ A / B / C / D / E / (F)	–	N/A (BR ~ Class D (4))	6+npd	4	1+npd
AT (5)	2012 / 2021	ÖNORM B 8115-5 (2021)	A / B / C / D / (E)	–	N/A (BR ~ Class C (6))	5	~ 2	~ 2
ES	2021	UNE 74201 (2021)	A / B / C / D / E / (F) and npd	–	N/A (BR ~ Class D)	6+npd	3	2+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 (7)	A / B / C / D / E / F	+	Class C	6	2	3
ISO/TS	2021	ISO/TS 19488 (2021) (8)	A / B / C / D / E / F and npd	N/A	N/A	6+npd	N/A	N/A

Table 2: Occupants' expected satisfaction for acoustic classes according to DS 490:2018 [13]. Summary based on DS 490.

Sound insulation between dwellings Main class criteria A-F in DS 490:2018		
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
E	$R'_w \geq 45$ dB	$L'_{n,w} \leq 63$ dB
F	$R'_w \geq 40$ dB	$L'_{n,w} \leq 68$ dB
Reference: DS 490:2018 "Lydklassifikation af boliger" (Sound classification of dwellings)		

Characteristics of DS 490 sound classes for dwellings and occupants' expected evaluation Information from DS 490:2018		
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.	70-85 %	< 10 %
Sound class intended as the minimum for new buildings.	50-65 %	< 20 %
Sound class intended for older buildings with less satisfactory acoustic conditions, e.g. for renovated dwellings.	30-45 %	25-40 %
Sound class intended for older buildings with unsatisfactory acoustic conditions.	10-25 %	45-60 %
Sound class intended for older buildings with clearly unsatisfactory acoustic conditions.	< 5 %	65-80 %
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.		

Table 3 is from VDI 4100 [15] and shows for the three three sound insulation classes (SSt) occupants' perception of typical noises from neighbouring dwellings in apartment houses.

Table 3: Perception of customary noises from neighbouring dwellings and allocation to three class of sound insulation between rooms (SSt) in apartment houses. Source: Table 1 from VDI 4100 [15]

Row	Type of noise emission	Perception of noise from neighbouring dwellings in apartment houses typical evening A-weighted background noise level of 20 dB and customary large living rooms assumed		
		SSt I	SSt II	SSt III
1	Loud speech	unclearly intelligible	barely intelligible	in general not intelligible
2	Raised speech	in general barely intelligible	in general not intelligible	not intelligible
3	Normal speech	in general not intelligible	not intelligible	not audible
4	Very loud music parties	very clearly audible	clearly audible	still audible
5	Loud music, loudly adjusted radio and television sets	clearly audible	still audible	barely audible
6	Music at normal volume	still audible	barely audible	not audible
7	Playing children	audible	still audible	barely audible
8	Walking noise	in general barely disturbing	in general not disturbing	not disturbing
9	User noises	audible	still audible	in general not audible
10	Noise from building service installations	unreasonable annoyance are in general avoided	in general not disturbing	not or only seldom disturbing
11	Household appliances	still audible	barely audible	in general not audible

The information in Table 3 provides a much more useful understanding of the perception of various noises for occupants than Table 2. The table shown is from VDI 4100 [15], because it's in English and fairly short. Two other classification schemes, DEGA 103, [16], [17], and ÖNORM B 8115-5 [18] also have similar tables (in German) with the same purpose, but longer due to more classes. Many people looking for a new home or wanting to understand their current situation would appreciate to be aware of the acoustic quality of dwellings and get access to such information, but typically it's not available, not even on request.

Acoustic labelling of dwellings

While energy labelling is mandatory for dwellings for sales or rent, that's unfortunately not the case for acoustic quality labels. Germany seems to have a higher focus on acoustic performance of dwellings, and as far as the author of this paper understands, fulfilment of minimum requirements in DIN 4109-1 [5] is not considered sufficient by customers, who expect a higher performance, and sometimes legal struggles or lawsuits are initiated, implying that if only minimum limits are fulfilled, it should be described in the contract.

Public knowledge and awareness about acoustic performance seems limited. Templates for acoustic quality test certificates are included in DAGA 103, [16]-[17], and in ÖNORM B 8115-5 [18], but the actual quantitative use of certificates is not known.

Some people believe that fulfilling regulations means that you cannot hear neighbours or at least not get disturbed. That is not the reality, cf. e.g. the DIN 4109-1 introduction. In Table 2, it is seen that for the Danish Class C corresponding to the current Danish regulations for new-build, only 35-50 % are expected to find the sound insulation good or very good, and up to 20 % poor. These statements help understanding that higher acoustic classes are important, but since large parts of the housing stock are old, also lower classes are needed.

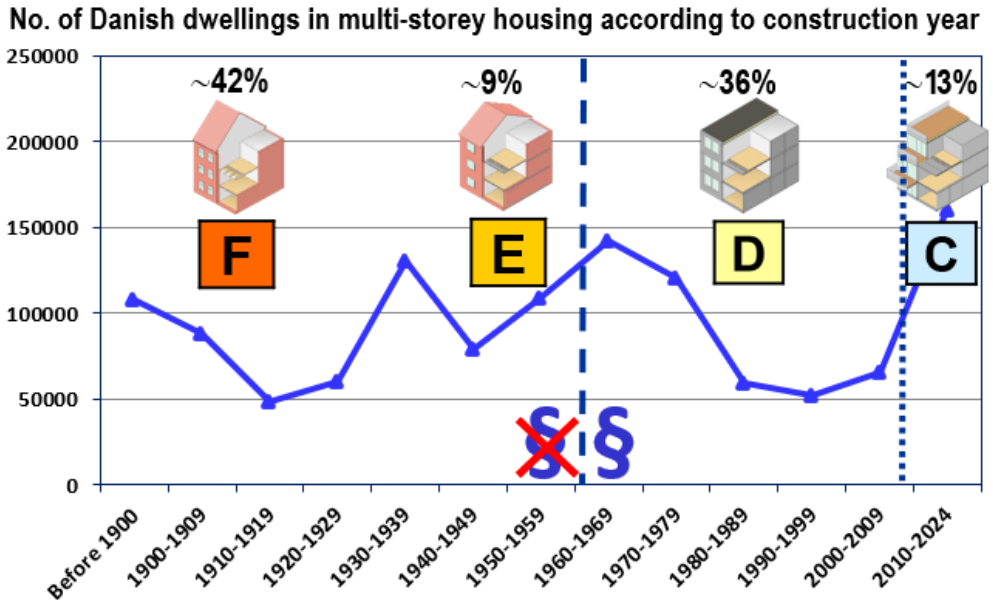

Figure 1: No. of Danish dwellings 1900-2024 in multi-storey housing according to construction year [19]. Estimated acoustic classes F, E, D, C according to DS 490:2018 [13] are indicated.
Note: Time periods 10 years, except the first & last column. The dashed line indicates year 1961 with the first national building regulations. The dotted line indicates year 2008 with stricter sound insulation limit values.

In Figure 1 is found an overview of the Danish multi-storey housing stock with indications of percentage of construction types in different time periods and estimated acoustic quality class according to [13].

Based on various publications, incl. magazines/newspapers and research articles, e.g. [20], [3] and [4], it becomes obvious that most occupants support acoustic labelling, while contractors, real estate agents and builders typically are against. Parts of the building industry fight against serious attention to acoustic conditions, claiming that it is too expensive and not needed (people too sensitive). For renovation the same arguments appear, and in addition claiming that it's impossible – even if construction options have not been investigated.

In a recent field case study in Denmark in old housing (up to approx. 100 years), it was found that by installing a new independent ceiling (12 cm height), the acoustic class changed from the lowest class F in DS 490 to C, the current limits, see Table 2.

Better acoustic conditions in housing would benefit from improved enforcement of regulations, [8],[21], stricter renovation rules [14] and use of acoustic labelling, preferably mandatory [22]. Considering contacts and statements from people having severe sleeping problems and other neighbour noise annoyances, cf. e.g. [3], [4] and [12], and in addition conflicts, it appears clear that for many people both health and quality of life suffer from neighbour noise.

Contents of many national classification schemes could benefit from more cooperation between countries. In the German DEGA103, [16],[17], there are more features worth considering, one of them being the verbal descriptions of neighbour noises for various classes, which might also be considered in a potential revision of [23].

The changes indicated would also support UN SDG goals (2025). SDGs 3 and No. 11, "Good health and wellbeing" and "Sustainable cities and communities" [24].

Discussion, conclusions and recommendations

A dwelling is most often the largest investment in lifetime and has a huge influence on economy and everyday quality of life. For safety reasons fire resistance and stability must never be compromised, and if correctly designed and constructed, people will not think about it. In contrast, acoustic conditions are experienced 24h/7d, implying a need for more awareness, both for renovation of housing and New-build.

Summary of findings and recommendations:

- Enforcement of regulations varies both in and between countries but should always be respected to ensure fulfilment of requirements, cf. [8]. Primarily a national issue.
- Subjective descriptions of classes could be included in more national acoustic classification schemes and might be considered for the potential revision of ISO/TS 19488 [23].
- Neighbour noise should always be included in national and European surveys about living conditions – thus getting the same status as traffic noise.
- Occupants of dwellings should have "open access" to acoustic performance. Mandatory labelling [22] should be introduced as soon as possible, starting with New-build.
- Creating more public awareness about the adverse influence of neighbour noise in housing and enhance consumer rights concerning access to acoustic quality.
- Information about acoustic performance/class for dwellings should be mandatory in advertisements – as for energy.

Based on findings and quoted literature, it's hopefully obvious that sound insulation in housing is strongly related to health and quality of life. It's not just a question about comfort/luxury, but it's about protection from noise annoyances in everyday life. Proper regulations and enforcement would support a healthy life and sustainable cities as explained in UN SDGs 3 and 11 [24].

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Links: https://sdgs.un.org/goals, https://sdgs.un.org/goals/goal3; https://sdgs.un.org/goals/goal11.