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## Sound classification schemes in Europe - Quality classes intended for renovated housing

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**ABSTRACT:** According to social surveys in several European countries, occupants of multi-family housing are considerably annoyed by noise from neighbours' activities. The noise issue has also received increasing attention from WHO. Neighbour noise has been identified as a health problem and reduction of noise exposure in the home included in the proposed main objectives for a housing policy. In most countries in Europe, building regulations specify minimum requirements concerning acoustical conditions for new dwellings. In addition, several countries have introduced sound classification schemes with classes intended to reflect different levels of acoustical comfort. Consequently, acoustic requirements for a dwelling can be specified as the legal minimum requirements or as a specific class in a classification scheme. Most schemes have both higher classes than corresponding to the regulatory requirements and at least one class with lower criteria intended for renovated dwellings, if improvement up to requirements is inappropriate or impossible for architectural, technical or economic reasons.

### 1 INTRODUCTION

In most countries in Europe, building regulations specify minimum requirements concerning acoustical conditions for new dwellings. The requirements relate to airborne and impact sound insulation, noise levels from traffic and technical installations as well as other acoustical and noise aspects.

Several countries have identified needs for more levels of acoustic quality of dwellings than defined by the legislation. To meet the needs, sound classification schemes with classes corresponding to different levels of acoustical comfort have been developed and introduced.

Consequently, acoustic requirements for a dwelling can be specified as the legal minimum requirements or - if available - as a specific class in a classification scheme. While legal sound insulation requirements for dwellings have existed for more than 50 years in several countries, schemes describing classes of acoustic quality of dwellings have been introduced during the past 1-2 decades.

Higher classes than the regulatory minimum requirements are requested as an option for new housing. For existing housing, and especially when renovating housing, it is often not a realistic option to comply with the current regulations, and thus there is also a need for lower classes to enable specification of performance class for such housing.

Sufficient sound insulation is related to the needs of the occupants and concern health, comfort, privacy and avoidance of conflicts.

This paper focuses on sound insulation between dwellings in multi-storey housing. Facade sound insulation is only dealt with briefly, although it is also an important issue.

## 2 ACOUSTICAL COMFORT AND HEALTH ASPECTS

The World Health Organisation (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”, cf. [1]. Based on this definition, noise effects on health should not simply be understood as the adverse physical effects due to noise exposure, but also as disturbance of well-being, i.e. psychological effects of noise, which in the long term may lead to adverse physical effects. WHO identified a considerable number of specific adverse health effects caused by environmental noise, cf. [2]. These effects can be medical conditions, but can also include sleep disturbance, stress etc.

The relevance of the sound insulation issue is underlined by results from social surveys, see eg [3b], and it is concluded that the neighbour noise problem is significant. Detailed results based on the WHO survey are found in for example [3-6]. When ranking annoyance from different noise sources, road traffic noise is the most dominant source, followed by neighbour noise. Based on statistics about populations [7] and findings presented in [3b], it seems that more than 50 million Europeans are exposed to neighbour noise causing adverse effects on quality of life.

### 2.1 Acoustical comfort, privacy, health, conflicts

Acoustical comfort can be characterized as follows:

- ◆ Absence of unwanted sound.
- ◆ Desired sounds with the right level and quality.
- ◆ Opportunities for activities without being heard by other people or annoying them.

It is important to observe that acoustical comfort for a person is related to the person not only as a receiver of sound, but also as a source of sound. It can be annoying to be exposed to noise from neighbours, but it can be equally annoying to know that your activities can be heard by other people, implying lack of privacy. Poor sound insulation between dwellings can be a cause of conflict and a cause of restrained activity or reduced well-being, cf. for example Figure 1.

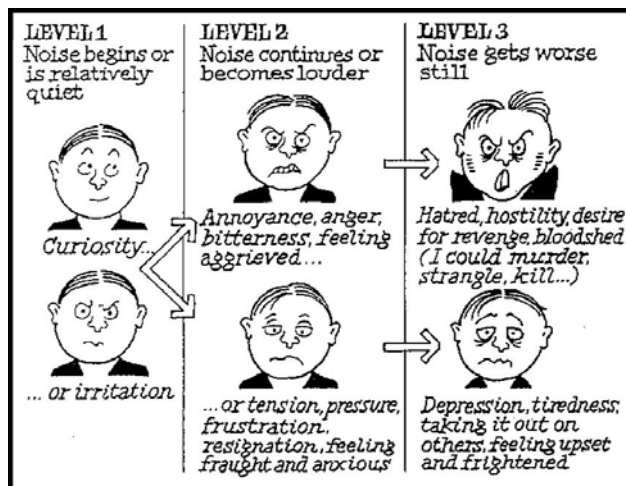


Figure 1. The noise reaction process.  
From [8].

In modern society people generally demand more comfort, including request for privacy. Additional challenges are new lifestyle trends, such as bare floors, powerful home entertainment equipment and a more flexible lifestyle with a tendency to break down divisions between traditional daytime and night time activities.

### 2.2 Sound insulation is a 'hidden' quality

In spite of the facts that a dwelling is probably the biggest investment during most people's lifetime, that much time is spent in the dwelling, and that acoustical comfort is very important for well-being, objective information about the acoustic conditions is rarely available.

This means that prospective occupants of a dwelling may find it hard to assess the acoustic quality, as this is a 'hidden' quality difficult to assess during a brief visit to the dwelling.

Classification schemes could be the tool to address the need for "labelling", see Section 4.

### 3 REGULATORY SOUND INSULATION REQUIREMENTS IN EUROPE

#### 3.1 Sound insulation between dwellings

A comparative study of the regulatory sound insulation requirements in 24 countries in Europe is described in [9-10]. The comparison reveals significant discrepancies in descriptors and requirements. For both airborne and impact sound insulation requirements, several descriptors are applied in Europe. Examples of descriptors applied:

- ◆ Airborne sound insulation, e.g.:  $R'_w$ ;  $R'_w + C$ ;  $R'_w + C_{50-3150}$ ;  $D_{nT,w}$ ;  $D_{nT,w} + C$
- ◆ Impact sound pressure level, e.g.:  $L'_{n,w}$ ;  $L'_{n,w} + C_{1,50-2500}$ ;  $L'_{nT,w}$ ;  $L'_{nT,w} + C_I$
- ◆ Besides, there are variants; recommendations and special rules

The most recent version of the standard EN ISO 717 [11] has contributed to the diversity in Europe by allowing many different descriptors and by introducing spectrum adaptation terms with different extended frequency ranges. Measurements are made according to [12].

The main requirements on airborne and impact sound insulation are presented in Figure 2 and 3. In order to facilitate a comparison between countries, all requirements have been converted into estimated equivalent values of  $R'_w$  and  $L'_{n,w}$  based on assumptions about rooms and construction types. In case of the equivalent  $R'_w$  being an interval, the average value has been indicated. The equivalent values are estimates only, as exact conversion is not possible.

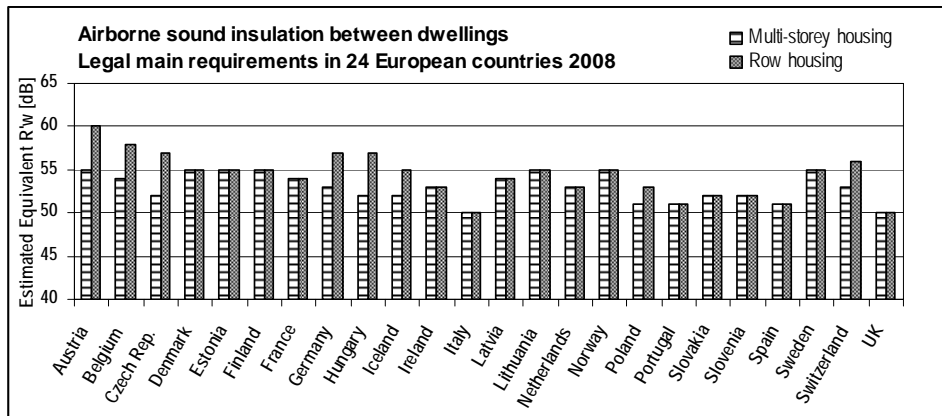


Fig.2: Overview of airborne sound insulation requirements between dwellings. Graphical presentation of estimated equivalent values of  $R'_w$ . Note: The results indicated for UK apply to England and Wales only.

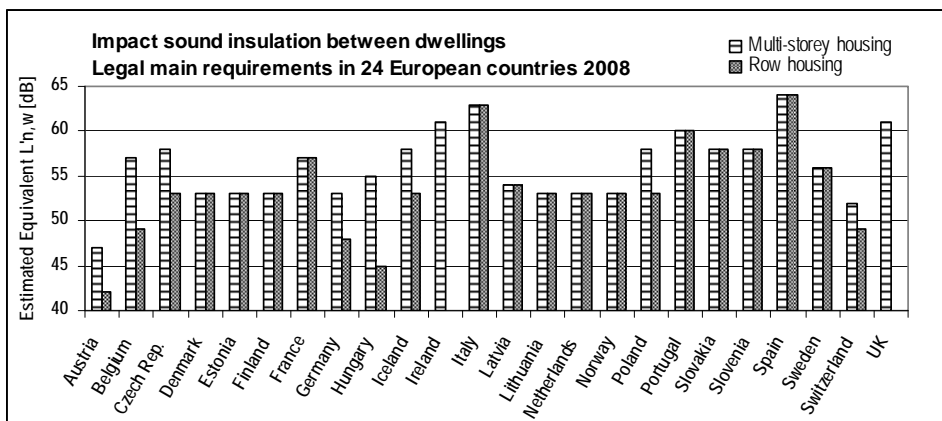


Fig.3: Overview of impact sound insulation requirements between dwellings. Graphical presentation of estimated equivalent values of  $L'_{n,w}$ . Note: The results indicated for UK apply to England and Wales only.

The results in Figures 2 and 3 show big differences between countries, especially for impact sound insulation requirements with max differences of equivalent  $L'_{n,w}$  limits more than 15 dB for multi-storey housing. For more detailed analysis of findings, see [9-10].

### 3.2 Sound insulation of facades

This paper focuses on sound insulation between dwellings, not facades. However, action plans according to the Environmental Noise Directive [13] will be implemented during the coming years, implying that traffic noise intruding from the outside could be considerably reduced. The primary goal is to reduce outdoor noise levels by reducing emissions from vehicles and to increase facade sound insulation, where necessary, to obtain satisfactory indoor conditions. The activities are described in several publications, see e.g. strategy paper [14] about research for a quieter Europe (related to environmental noise only). A new WHO guideline [15] reviews the health effects of sleep disturbance and presents limit values of night noise exposure.

A consequence of improved facade sound insulation could be neighbour noise appearing much louder than before, where it might have been masked by traffic noise. Thus, it can be expected that the percentage of people hearing their neighbours' activities and being annoyed by these will increase and that sound insulation in multi-family houses might become even more important.

## 4 EUROPEAN SCHEMES FOR SOUND CLASSIFICATION OF DWELLINGS

The classification schemes describe different quality classes to meet different needs of activities and quietness in the home. In 4.1 an overview of schemes in Europe is found. In 4.2 the importance of having verbal explanations of classes to make differences between classes understandable to ordinary people is addressed.

### 4.1 Overview classification schemes in Europe

Sound classification schemes in Europe are national schemes, the majority being published by national standardization organizations. An overview of existing sound classification schemes for dwellings, relations to building codes and classes intended for existing housing is found in Table 1. The schemes and main criteria are described in more detail in [16], for facades in [17].

Table 1: Overview European schemes for sound classification of dwellings, relation to building codes and indication of classes for renovated dwellings

Country	Class denotations <sup>(1)</sup>	CS Reference (latest version)		BC link to CS	BC reference to CS	Comment	Classes for renovated dwellings
DK	A / B / C / D	DS 490 (2007)	[18]	+	Class C		D
FI	A / B / C / D	SFS 5907 (2004)	[19]	(+)	(Class C)	BC ~ Class C	D
IS	A / B / C / D	IST 45 (2003)	[20]	(-)	None <sup>(3)</sup>		D
NO	A / B / C / D	NS 8175 (2008)	[21]	+	Class C		D
SE	A / B / C / D	SS 25267 (2004)	[22]	+	Class C		D
LT	A / B / C / D / E	STR 2.01.07 (2003)	[23]	+	Class C		D, E
NL	I / II / III / IV / V	NEN 1070 (1999)	[24]	-	None	BC ~ Class III	IV, V
DE	III / II / I	VDI 4100 (2007)	[25]	-	None	BC ~ Class I	None
FR	QLAC / QL <sup>(2)</sup>	Qualitel (2008)	[26]	-	None	(4)	None

Abbreviations: BC = Building Code (regulatory requirements); CS = Classification scheme

(1) Classes are indicated in descending order, i.e. the best class first.

(2) The indicated class denotations are applied for sound insulation between dwellings, but there is only one performance level for e.g. facade sound insulation.

(3) For sound insulation between dwellings, BC recommends limit values as for Class C, although the regulatory requirements in the BC are weaker than Class C.

(4) Class/label QL for airborne sound insulation between dwellings equals BC requirement. For impact sound level, QL is 3 dB stricter than the BC.

The German Society of Acoustics (DEGA) has published a recommendation for labelling of acoustic quality of new and existing buildings, cf. [27]. The labelling system has 7 classes de-

scribed by a letter (A-F) and a colour code, the lower classes intended for old buildings. More schemes – different from all others, unfortunately - are under development in other countries.

#### 4.2 How to explain protection provided

The different classes in the classification schemes are intended to reflect different levels of acoustical comfort. Thus, to be able to make a qualified choice of sound class, it is relevant to know the degree of acoustical comfort or occupants' satisfaction for the respective classes.

**Example 1:** Concerning regulatory sound insulation requirements for dwellings, the Danish Building Regulations 2008 refer to Class C in DS 490:2007. This standard also defines limits for dwellings with better acoustic conditions (Classes B and A) than in the regulatory minimum requirements (Class C). Furthermore, the standard also includes a weaker Class D intended for existing dwellings, where improvement up to Class C is not a choice for architectural, technical or economic reasons. In DS 490 are found brief definitions of classes, and an Annex describes in more detail the occupants' expected subjective evaluation. Summarized information based on DS 490 is found in Table 2.

**Example 2:** VDI 4100 has a descriptive approach referring to everyday sounds, cf. Table 3.

Table 2: Occupants' expected satisfaction for different sound classes according to DS 490:2007.

Sound classes describing acoustic conditions in dwellings		Occupants' evaluation	
Class	Characteristics according to DS 490 Summary based on information in DS 490	Good or very good	Poor
<b>A</b>	<b>Excellent acoustic conditions</b> Occupants will be disturbed only occasionally by sound or noise	> 90%	
<b>B</b>	<b>Considerable improvement compared to minimum given in class C</b> Occupants may be disturbed sometimes by sound or noise	70 to 85%	< 10%
<b>C</b>	<b>Sound class intended as minimum requirement for new buildings</b> Less than 20% of occupants are expected to be disturbed by sound or noise	50 to 65%	< 20%
<b>D</b>	<b>Sound class for older buildings with less satisfactory acoustic conditions</b> Intended for e.g. renovated dwellings. Not intended for new buildings.	30 to 45%	25 to 40%
<b>Note:</b> Within each sound class the percentage satisfied or dissatisfied occupants may differ somewhat from one acoustic criterion to another. The grouping is mainly based on the subjective assessments of airborne sound between dwellings and impact sound from adjacent dwellings. For details, see DS 490.			

Table 3: Perception of customary noises from neighbouring dwellings and assignment to three sound insulation classes (SSt). Ref.: VDI 4100 [25], Table 1. Note: SSt I corresponds to legislation in Germany.

Type of noise emission	Perception of immission from neighbouring dwelling Assumptions: • Typical evening A-weighted background noise about 20 dB • Customary large living spaces assumed		
	SSt I	SSt II	SSt III
Loud speech	intelligible	in general intelligible	in general not intelligible
Raised speech	in general intelligible	in general not intelligible	not intelligible
Normal speech	in general not intelligible	not intelligible	not audible
Walking noise	in general disturbing	in general no more disturbing	not disturbing
Noise from building service installations	unreasonable annoyances are in general avoided	occasionally disturbing	not or only seldom disturbing
Music, loudly adjusted radio and television sets, parties	clearly audible		in general audible



## 5 DISCUSSION

When designing new housing or renovation of existing housing, it is important to decide, which sound class is appropriate. In practice, the choice of sound class cannot be changed to a better one afterwards – or it is very expensive. If dwellings don't provide a good atmosphere to the occupants, it is not a real home. Thus, in such cases, the design is not long-lasting and cannot be considered “sustainable”.

Based on the findings and surveys carried out, see findings in [9-10], it can be concluded that in several countries, even for new housing, the sound insulation between neighbouring flats does not necessarily provide acoustical comfort for the occupants. Some WHO findings are summarized in Section 5.1. The challenges seem overwhelming, and a strategy is needed.

### 5.1 Findings from WHO housing survey

In 2002–2003, the WHO LARES Survey (Large Analysis and Review of European Housing and Health Status) was carried out, cf. [3-5]. The survey was designed to achieve four objectives, one of them being to improve knowledge of the impacts of existing housing conditions on health and mental and physical well-being. The survey included about 8500 people from about 3400 households. When ranking noise annoyance, it was concluded, cf. Section 3, that road traffic is the most dominant noise source followed by neighbour noise. Some conclusions related to the LARES study are found in [5]:

- ◆ The LARES study confirmed on an epidemiological level the thesis that neighbour noise affects health if it results in long-lasting severe annoyance.
- ◆ Neighbour-noise-induced annoyance is therefore a highly underestimated risk factor for healthy housing. With this background, increased requirements for sound insulation between dwellings should be accepted as obligatory in multi-family housing.

Based on LARES, WHO identified neighbour noise as a health problem, and reduction of noise exposure in the home was included in the proposed main objectives for a housing policy.

### 5.2 Is sound insulation in housing of any interest to society?

Public health is of interest to society for economic reasons. Furthermore, to keep stability and avoid conflicts between neighbours, it is of public interest that the inhabitants are satisfied with the housing conditions. Otherwise, some people might move to more attractive locations, leaving behind those with fewer resources and thus influencing the population balance. Regulatory sound insulation requirements primarily aim at ensuring a reasonable sound insulation in new housing and should also be applied as far as possible, when rebuilding or renovating housing. For existing housing in general, other initiatives must be applied to increase sound insulation, where needed. It is important to be able to define “reasonable sound insulation” in a way that enables objective criteria to be set in the legislation, so the performance as perceived by the occupants correlates well with the objective performance, cf. [10].

### 5.3 Homes for the future?

In the WHO LARES survey about European housing [4], it is concluded: “Looking back in time, the housing stock development does not match the social changes and the gain in life expectancy of the last decades. Today, people spend years and years in dwellings that have not been designed to meet the needs and lifestyles of the moment as well as the needs and lifestyles of the future”. Neighbour noise is identified as a health problem, and reduction of noise exposure in the home is included in the proposed objectives for a policy.

In the conclusions in [4], housing is defined as follows: “Housing is the conjunction of dwelling, home, immediate environment and community. The role of public health is to provide circumstances under which people can be healthy”.

The sound insulation needed depends on the sound levels and activity types in the neighbours' dwellings, as well as on the expectations to the “quietness” in own dwelling. Typical sound levels for different activities and sound insulation needs are found in e.g. [28] and



[29]. It is important to realize that most regulatory minimum requirements are designed to provide satisfactory sound insulation for people with “normal” sensitivity and neighbours with “normal” behaviour.

National initiatives related to existing housing could include:

- ◆ Sound insulation requirements to be enforced, when rebuilding or renovating housing.
- ◆ Develop design solutions and guidelines for improvement of sound insulation.

## 6 COST Action TU0901

A joint European Action, COST Action TU0901 “Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions” [30], has been established in 2009 and runs for four years. Until now (March 2010), 26 countries have signed up for TU0901, and about 80 people have been nominated for the management committee and the working groups.

### *Main objectives*

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

WG1: Harmonized sound insulation descriptors and classification schemes in Europe

WG2: Subjective evaluation of sound insulation - Laboratory tests and harmonized field surveys

WG3: Design and acoustic performance of building constructions for multi-storey housing

In WG3, the main tasks are:

- ◆ Collection and discussion of construction details and sound insulation data.
- ◆ Prepare a European database with traditional and innovative “robust” solutions for sound insulation of new dwellings and for improvement of existing dwellings.

The joint efforts defined are aiming at reducing the diversity in Europe and at supporting and initiating – where needed – improvement of sound insulation of new and existing dwellings in Europe to the benefit of the inhabitants and the society.

## 7 CONCLUSIONS

Several countries in Europe already have sound classification schemes for dwellings. All schemes are different and development of new – unfortunately also different – schemes in more countries are in progress.

In COST Action TU0901, joint efforts are made towards a more harmonized approach, thus allowing national findings and experience to be utilized in other countries with the advantage of better solutions and faster progress. The ultimate goal is that dwellings in new housing as well as existing housing reach a quality providing well-being, cf. WHO definition of health, for the occupants of the dwellings and thus value for the community.

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