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SOUND CLASSIFICATION OF DWELLINGS IN THE NORDIC COUNTRIES

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1. INTRODUCTION

A draft standard INSTA 122:1997 on sound classification of dwellings has been proposed as a common national standard in the Nordic countries (Denmark, Norway, Sweden, Finland, Iceland) and in Estonia. The draft standard specifies a sound classification system with four classes A, B, C and D, where class C is proposed as the future minimum requirements for new dwellings. The classes B and A define criteria for dwellings with improved or very good acoustic conditions, respectively, whereas class D is intended for older dwellings in which the acoustic quality level of a new dwelling cannot reasonably be met. The classification specifies limit values for airborne sound insulation, impact sound pressure level, reverberation time, sound pressure levels (noise levels) in the dwellings from indoor or outdoor noise sources, like technical installations in the same building or buildings nearby, transport, industry or other sources.

The purpose of the standard is to offer a tool for specification of a standardized acoustic climate and to promote constructors to improve the acoustic qualities of dwellings so that better conditions than the requirements of the building regulations may be obtained.

2. SCOPE

The requirements for sound conditions for dwellings are divided into two categories due to their different characteristics. The first requirement category describes the acoustic quality of the building itself whereas the second category describes the environmental conditions around the building of concern. The conformity of a dwelling or a building with a sound class is documented by measurements in the completed dwelling or building. Both indoor and outdoor sound climate shall be documented.

Sometimes the classification of a dwelling may be desirable at areas where the environmental (outdoor) conditions of a dwelling do not meet the requirements for any of the sound classes which are specified in the standard. Then, an indoor sound classification may nevertheless be made for the dwelling in terms of that the outdoor sound conditions are carefully documented and reported.

3. THE CLASSIFICATION SYSTEM

In the classification system there is no distinction between different types of dwellings, i.e. multifamily houses, row houses and single family houses are evaluated in the same way. However, the highest class A will normally not be relevant in multifamily houses. The step size from one class to the next is basically 5 dB (except reverberation time), but in addition there are some extended acoustic requirements in the higher classes, A and B. The four sound classes may be characterized as follows:

Sound class A: Sound class equivalent to a especially good sound climate where the inhabitants only occasionally will be disturbed by sound or noise.

Sound class B: Sound class with a marked better sound climate than the minimum requirements for building regulations given in class C. Inhabitants may be disturbed in some cases.

Sound class C: Sound class corresponding to the intentions of the minimum requirements in the building regulations. Up to 15 % to 20 % of the inhabitants may be disturbed.

Sound class D: Sound class intended for older buildings with a less satisfactory sound climate. May normally not be used for new buildings.

Sound class	Airborne sound insolation (dB)	Impact sound pressure level (dB)	Noise level $L_{A,eq}$ (dB)
Sound class A Very good sound conditions.	≥63*	≤43*	≤20
Sound class B Satisfactory sound conditions.	≥58*	≤48*	≤25
Sound class C Acceptable sound conditions.	≥55	≤53	≤30
Sound class D Less satisfactory sound conditions.	≥50	≤58	≤35

*Table 1. Overview of main criteria for sound classes. *: Frequency range extended down to 50 Hz according to EN ISO 717.*

4. AIRBORNE SOUND INSULATION

In the Nordic countries the present airborne and impact sound insulation requirements for buildings are expressed as minimum R'_w and maximum $L'_{n,w}$ values based on the traditional building acoustic frequency range, 100 - 3150 Hz. However, a growing need to include the low frequency sound insulation has been recognized. Low frequency problems may be increasing due to a building construction trend towards more light-weight constructions allowing a stronger low frequency transmission of sound, e.g. from music and from footfall.

The revised standards for rating of airborne and impact sound insulation EN ISO 717-1:1996 [2] and EN ISO 717-2:1996 [3] open up the possibility to apply spectrum adaptation terms for an extended frequency range by adding so-called C-corrections when specifying sound insulation of buildings and requirements. In order to avoid low-frequency problems in the higher quality sound classes A and B, the limits for sound insulation based on the new methods for extended frequency range were chosen.

The extension of the frequency range towards lower frequencies does imply significant consequences. In a project of the NKB Acoustic Group (Nordic Committee on Building Regulations) it was decided to investigate the behaviour of the new spectrum adaptation terms [4]. Measurement results from field measurements in the extended frequency range down to 50 Hz were collected from typical recent houses in the Nordic countries. For airborne sound insulation the main results are summarised in Table 2. The results show that for constructions of concrete and porous concrete the average value of the C-correction in the extended frequency range is -2 dB. Lightweight constructions from wood or gypsum are evaluated more strict than concrete constructions, as expected.

Type of construction	Number of measure-ments	$C_{50\text{-}5000}$ Average	Min.	Max.
Concrete	9	-2.0 dB	-3 dB	-1 dB
Porous concrete	23	-2.0 dB	-4 dB	-1 dB
Wood, hardboard	15	-3.5 dB	-6 dB	-1 dB
Gypsum board	19	-5.3 dB	-14 dB	-2 dB

Table 2. Values of the low frequency spectrum adaptation term for airborne sound insulation as found in field measurements from the Nordic countries. Based on data collected by Hagberg [4].

The results given in Table 2 imply that the limit of $R'_w + C_{50\text{-}5000} = 58$ dB in class B corresponds to approximately $R'_w = 60$ dB for concrete constructions and to values of R'_w between 60 and 72 dB for gypsum board constructions.

The main requirements for airborne sound insulation, as given in Table 1, are valid between a dwelling and other spaces outside the dwelling. A 5 dB higher limit shall be fulfilled between a dwelling and premises for work or service with noisy activities. In class A and B there is also specified a minimum sound insulation inside the dwelling between at least one habitable room and other spaces in the same dwelling. These interior limits are 15 dB below the main limits.

5. IMPACT SOUND PRESSURE LEVEL

The behaviour of the new spectrum adaptation term for impact noise [3] was also investigated through a collection of measuring results from field measurements on typical building constructions [4]. If the constructions are divided into three groups the results of this investigation are seen in Table 3. Only results from vertical transmission are used.

Type of construction	Number of measure-ments	$C_{I,50\text{-}2500}$		
		Average	Min.	Max.
Heavy	27	-3.2 dB	-11 dB	1 dB
Medium	53	1.5 dB	-2 dB	5 dB
Light	62	2.4 dB	-2 dB	13 dB

Table 3. Values of the low frequency spectrum adaptation term for impact noise as found in field measurements from the Nordic countries. Based on data collected by Hagberg [4].

Heavy constructions include concrete and hollow concrete. Medium-weight constructions are leca, EW-slab (combination of concrete and wood), and some other constructions. Light-weight constructions include wood, hardboard, gypsum and porous concrete. The results show a difference of around 6 dB between the average values in the heavy and light categories. However, the total spread is from -11 dB to +13 dB.

From this it is clear, that if the C-correction in the extended frequency range is taken into use, it will be more difficult for light-weight constructions to fulfil a certain impact sound requirement, whereas heavy constructions would be evaluated more optimistic. In fact it could be claimed that a negative value of the C-correction should not be used, as this will typically appear in case of a hard floor surface, which gives footfall noise in the high frequency range. So, if negative C-corrections are allowed, there is a great risk to introduce high frequency problems for heavy constructions with hard floor coverings. For this reason it is said in the INSTA standard that only unfavourable values of the spectrum adaptation term shall be considered, i.e. $C_{I,50\text{-}2500} \geq 0$ dB.

The main requirements for impact sound pressure level as given in Table 1 are valid in habitable rooms when measured from other dwellings and common spaces. A 5 dB lower limit shall be fulfilled when measured from premises for work or service with noisy activities. Class A and B also specify sound insulation limits inside the dwelling in at least one habitable room from another space in the same dwelling. These limits are 15 dB less strict than the main limits.

6. REVERBERATION TIME

The specified limits are related to space averaged reverberation time in each of the octave bands 500, 1000 and 2000 Hz. In stairwells, corridors etc. the highest value of the reverberation time shall not exceed 1.0 s in the classes A and B, and 1.3 s in the classes C and D.

7. INDOOR NOISE LEVEL

The requirements of indoor noise levels are divided into three types of noise sources: noise from technical installations (i.e. building services), noise from transport sources and noise from other sources.

7.1 Indoor noise level from technical installations.
The main limits as given in Table 1 refer to the A-weighted sound pressure level $L_{A,eq,T}$ from stationary continuous noise sources with a relatively short measuring time depending on the actual sound source. Additionally, in the classes A, B and C the C-weighted sound pressure level shall fulfil limits which are 20 dB higher, i.e. a limit of 50 dB in class C. The reason for having a combination of A-weighted and C-weighted noise limits is that the A-weighted noise limit alone is not sufficient to avoid cases of very annoying low-frequency noise. Although the inclusion of the C-weighted noise limit is far from perfect, the intention is to take care of most cases with possible low-frequency noise problems. The noise from short-time single noise sources is described by $L_{A,max}$ measured with time weighting F (fast). The corresponding noise limits in each class are 2 dB higher than the main limits given in Table 1.

7.2 Indoor noise level from transport sources.
The main limits as given in Table 1 refer to a 24 h measuring time, and they are related to the average yearly traffic flow. In the classes A, B and C and during night time (22-06 hours) the $L_{A,max}$ level shall not exceed limits, which are 15 dB higher than the main limits.

7.3 Indoor noise level from other sources.
The main limits as given in Table 1 refer to a 30 minutes measuring time during day and evening time. During night time (22-06 hours) a 5 dB lower noise limit shall be met in the classes B, C and D. In the classes A, B and C and during night time (22-06 hours) the $L_{A,max}$ level shall not exceed the $L_{A,eq}$ limits by more than 15 dB.

8. ENVIRONMENTAL CONDITIONS

As mentioned earlier the requirements of outdoor noise levels are divided into two types of noise sources: noise from transport sources and outdoor noise from other noise sources including technical installations (i.e. building services) related to the building of concern or to other buildings nearby. The limit values are shown in Table 4 and 5.

Type of space	Type of sound measure	Class A	Class B	Class C	Class D
In outdoor areas at least on one side of a dwelling	$L_{A,eq,24h}$ (dB)	45	50	55	60

Table 4. Outdoor sound pressure levels from transport sources. The highest values of A-weighted equivalent sound pressure levels, $L_{A,eq,24h}$

Type of space	Type of sound measure	Class A	Class B	Class C	Class D
In outdoor areas, at least on one side of the dwelling	$L_{A,eq,30\,min}$ (dB) daytime (06-18) evening (18-22) night (22-06)	 35 30 25	 40 35 30	 45 40 35	 55 50 45

Table 5. Outdoor sound pressure levels from technical installations and other noise sources. The highest values of A-weighted equivalent sound pressure levels, $L_{A,eq,30min}$

9. CONCLUSION

A system for acoustic classification of dwellings provides several advantages: (1) A tool to be used by consumers, building contractors and authorities to specify acoustic quality of new dwellings and of older dwellings to be renovated or restored; (2) Emphasis on the fact that the legislative acoustic requirements are minimum requirements; (3) An incentive to voluntarily specify and design for better acoustic quality than required in the building regulations. Thus, it is the hope that the introduction of sound classification of dwellings will lead to a general improvement of the acoustic quality of dwellings in the future.

10. REFERENCES

[1] INSTA Draft Proposal 122:1997. Sound classification of dwellings. Norwegian Council for Building Standardization, Oslo.
[2] EN ISO 717-1:1996. Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation
[3] EN ISO 717-2:1996. Acoustics - Rating of sound insulation in buildings and of building elements - Part 2: Impact sound insulation
[4] Hagberg, K. (1996). "Ljudkrav med stöd av ISO/DIS 717." (Acoustic requirements supported by ISO/DIS 717, in Swedish). NKB Committee and Work Reports 1996:02. Nordic Committee on Building Regulations, NKB, Helsinki, Finland.