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Impact sound insulation descriptors in the Nordic building regulations  
– Overview special rules and benefits of changing descriptors

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All Nordic countries have sound insulation requirements specified in the building regulations or in sound classification schemes, Class C, referred to in the regulations and published as national standards, which all originate from a common Nordic INSTA-B proposal from the 90's, thus having a lot of similarities. However, the descriptors and other rules differ more than what is obvious at the first glance. The present use of different descriptors and additional rules is partly a heritage from the past and partly caused by later national revisions without cooperation with the other Nordic countries. These national rules are not easy to find, unless all details of standards and other documents are known and studied carefully, and they cause problems since the building industry is not national anymore. This paper gives an overview of special national rules in the Nordic countries regarding impact sound insulation requirements and is related to an equivalent paper about airborne sound insulation requirements. The papers also describe the major benefits of reducing the number of special rules and of changing descriptors to those which best support protection of the residents and development of the building industry, both aspects in consideration of the European perspective and cooperation in COST Action TU0901.

## 1 Introduction

This paper deals with impact sound insulation descriptors, requirements and special rules in the Nordic countries and is coordinated with another paper with a related main topic, airborne sound insulation [1]. The two papers have the same main structure, some similar text paragraphs and the same introductory overview table. Both papers focus on multi-storey housing. In [1] is found brief information about national plans for changing the sound insulation requirements.

All Nordic countries have sound insulation requirements for different types of buildings, and since the mid 90's sound classification schemes have been implemented as national standards in all countries, one by one, in the period 1996 to 2004. In building codes and in classification schemes, different acoustic issues are addressed, like airborne and impact sound insulation, noise levels etc. An overview of regulations and sound classification schemes is found in Table 1.

Table 1: Sound insulation of dwellings.  
Overview Building codes and sound classification schemes in the Nordic countries - Status March 2010

Country	Building code (BC)	Classification scheme (CS) <sup>(1)</sup>	BC link to CS	BC reference to CS	BC References	CS References
Denmark (DK)	BR 2008	DS 490:2007	+	Class C	[2]	[7]
Finland (FI)	RAKMK C1:1998	SFS 5907:2004	(+)	(Class C)	[3]	[8]
Iceland (IS)	Byggingarreglugerð Nr. 441/1998	IST 45:2003	(-)	Class C recommended	[4]	[9]
Norway (NO)	TEK'97	NS 8175:2008	+	Class C	[5]	[10]
Sweden (SE)	BBR 2008	SS 25267:2004	+	Class C	[6]	[11]

(1) Class denotations A / B / C / D indicated in descending order, i.e. the best class first.

During different periods in history several attempts have been made to coordinate the sound insulation requirements in the Nordic building regulations. Last time an extensive attempt was made, was during the mid 90's. The work was partly funded by the Nordic Committee on Building Regulations, see reports [12-14], and by Inter Nordic STandardization – Building (INSTA – B), see [15]. At that time dedicated organizations existed in order to promote coordination between the Nordic countries. However, for different reasons, these organizations closed down, and the needs for updating requirements in the different Nordic countries were asynchronous. Combined with the fact that consensus was never attained, the consequence was that sound insulation requirements and classification schemes were developed in different directions in the Nordic countries. Additionally, since the late 90's until today, several further national revisions have been made in each country, implying that current legislation in the Nordic countries is even more diversified today than 10-15 years ago. Instead of cooperation and coordination, all new revisions have been made from national experiences solely, and changes were not only made by changing numbers and by following the international standards [16-17], but additional special rules were made and included in the regulations or in the classification standards, for example as notes or rules explained somewhere in the document - not necessarily in the tables with limit values - or even in other documents like eg guidelines.

The Nordic building industry suffers from the differences in requirements and special rules, since their building systems have to be adapted to national regulations in a small market. The Nordic market is today an “open market”. However, with regard to building regulations, the market is indistinct, thus impeding exchange of building systems and products.

## 2 Impact sound insulation requirements in the Nordic countries

The minimum requirements are stated in national building regulations, either directly, as in Finland and Iceland, or indirectly by referring to the national classification scheme, as in Denmark, Norway and Sweden. However, in Finland, the limits are identical in the building code and in the classification scheme, Class C, but the use of classification schema is voluntary. It is expected that Iceland will refer to the sound classification scheme in the revised building regulations expected in year 2011. In some countries the requirements are stated in the building regulations in advisory notes, which are normally not mandatory. However, if these are not followed, it is necessary to prove that the overall mandatory requirements still are fulfilled. Hence, in practice, the advisory notes are mandatory.

### 2.1 Limits impact sound

The impact sound limits, which have to be complied with in the Nordic countries, are stated in Table 2. The requirements appear to be the same in Norway, Finland and Denmark, both in terms of descriptor and level. Sweden and Iceland differ from the three other countries. However, there are some remarks about national special evaluation rules deviating from current rules standardized in ISO 140-7 and ISO 717-2, which actually make the figures differ from each other more than what could be expected, cf. remarks in Table 2 and Section 2.2.

Table 2: Regulatory requirements for impact sound insulation between dwellings in the Nordic countries

Country	Requirements found in	Requirements impact sound – March 2010	
		Impact sound [dB]	Remarks - For further details, see Table 3
SE	CS (Class C)	$L'_{n,w} \leq 56$ $L'_{n,w} + C_{1,50-2500} \leq 56$	National special rules (additional rules compared to ISO 140-7)
NO	CS (Class C)	$L'_{n,w} \leq 53$	National special rules (additional rules compared to ISO 140-7) It is recommended to include $C_{1,50-2500}$
FI	BC or CS (Class C) (Identical limits)	$L'_{n,w} \leq 53$	National special rules (additional rules compared to ISO 140-7)
DK	CS (Class C)	$L'_{n,w} \leq 53$	For light-weight constructions, it is recommended to include $C_{1,50-2500}$
IS	BC	$L'_{n,w} \leq 58$ Row housing: $L'_{n,w} \leq 53$ dB	National special rules (additional rules compared to ISO 717-2) Classification scheme is not yet referred to in the BC

Hence, when reading the text in each national document carefully, there are differences in many of these figures, even if they at a first glance appear to be equal. This causes unexpected problems and unnecessary costs for those who will comply with the class criteria or the regulations in the different countries. Norway, Finland and Denmark appear to apply the same level, however with all national additional rules they are rather different, so are Sweden and Iceland.

## 2.2 National special evaluation rules for impact sound

In some Nordic countries important exceptions are applied. These exceptions are not immediately visible in the regulations, and for those who are not working in the building acoustic area, the exceptions and special evaluation rules are not fully clear and not easy to understand. Even specialists may sometimes fail to find all special rules. The special rules found by the authors and by specialists from the other countries, [18], are summarized in Table 3 below.

Table 3: Special evaluation rules for impact sound insulation

Country	Special evaluation rules for impact sound insulation	Remarks
SE	<ol style="list-style-type: none"> <li>1. Receiving room volume limitation in the evaluation, <math>V_{r,max} \leq 31 \text{ m}^3</math></li> <li>2. Bathrooms excluded in case the level from service equipment is kept below some certain limits</li> <li>3. Floor (<math>1 \text{ m}^2</math>) immediately inside the entrance door is excluded</li> </ol>	$V_{r,max} = 31 \text{ m}^3 \rightarrow$ $L'_{n,w} = L'_{nT,w}$ when $V_r \geq 31 \text{ m}^3$
NO	<ol style="list-style-type: none"> <li>1. Receiving room volume limitation in the evaluation, <math>V_{r,max} \leq 100 \text{ m}^3</math></li> </ol>	Volume limit $V_{r,max} = 100 \text{ m}^3 \rightarrow$ $L'_{n,w} = L'_{nT,w} + 5 \text{ dB}$ when $V_r \geq 100 \text{ m}^3$
FI	<ol style="list-style-type: none"> <li>1. Receiving room volume limitation in the evaluation, <math>V_{r,max} \leq 60 \text{ m}^3</math></li> <li>2. Bathroom excluded</li> </ol>	Volume limit in [20]: $V_{r,max} = 60 \text{ m}^3 \rightarrow$ $L'_{n,w} = L'_{nT,w} + 3 \text{ dB}$ when $V_r \geq 60 \text{ m}^3$
DK	<ol style="list-style-type: none"> <li>1. Balconies and floors in rooms with floor area less than <math>2.5 \text{ m}^2</math> do not need to fulfil the requirements.</li> <li>2. For light-weight constructions it is recommended to extend the frequency range down to 50 Hz, applying <math>L'_{n,w} + C_{1,50-2500} \leq 53 \text{ dB}</math>.</li> </ol>	This is stated directly in DS 490 [7] just above the Table with limit values. This recommendation is found in a separate guideline [19].
IS	<ol style="list-style-type: none"> <li>1. The deviation may not exceed 8.0 dB in any single 1/3 octave band</li> </ol>	The former “8-dB rule” is still valid, but is expected to disappear in the next revision of the building code.

As an example, consider a typical modern apartment with an open plan solution furnished “normally” and with kitchen and living room connected, room volume  $125 \text{ m}^3$ , which is not unusual, reverberation time equal to 0.5 s. In Table 4 are found results from evaluating this case according to ISO 717, and additionally by following the national special rules.

Table 4: Example of deviations, taking national special rules into account and comparing to evaluation according to ISO 140-7 and ISO 717-2 ( $L'_{n,w}$  or  $L'_{n,w} + C_{1,50-2500}$ ) for room volume  $125 \text{ m}^3$  and room “normally furnished” ( $T = 0.5 \text{ s}$ )

Room, $V_r = 125 \text{ m}^3$	Evaluation procedure (example)		
For requirements, see Table 2 ( $L'_{n,w}$ or $L'_{n,w} + C_{1,50-2500}$ or both)	National special rules, according to Table 3	Value – using ISO 140-7 and ISO 717-2 solely	Remarks (valid for this example)
SE	56	62	3 dB difference in regulation results in 8 dB difference in reality. However, observe that Sweden also includes $C_{1,50-2500}$
NO	53	54	
FI	53	56	
DK	None	None	
IS	52, 55	-	The value can vary “randomly” depending on floor structure etc.

## 3 Compliance with regulations

Apart from the differences stated above, some other minor differences might confuse the market, and these differences and their effect on the national adaptations for various systems is far from clarified. Typical users might think that each measured value must fulfil the requirements. However, it is not always perfectly clear, if each single measured value really must comply with the requirement. In some countries, deviations in single values are accepted as long as the mean value fulfil the requirement. The number of measurements needed to fulfil the requirement in each country is - or should be - stated in each national standard. A brief overview of present national compliance rules is given in Table 5.

Table 5: Special rules in the Nordic countries, concerning compliance with regulations

Country	Special rules
SE	Deviations in single measurements is accepted as long as the mean value within one apartment fulfils the requirement level
NO	Every single value has to be fulfilled
FI	Every single value has to be fulfilled
DK	Average measurement results for same type of constructions shall comply with requirements, single results may exceed requirements by max 1 dB.
IS	Every single value has to be fulfilled

The rules in the Nordic countries do not necessarily follow practice in other European countries. For example some countries conclude that if the uncertainty is 1 dB, a field test result must be at least 1 dB better than the limit to be accepted by the authorities. For further discussions on this issue, rules in [22] and findings in [23] should be considered.

In addition to the issue of measurement uncertainty and related national compliance rules, other factors might influence, whether a building system fulfils the regulations or complies with a specific limit or not. As explained in Section 2 for impact sound insulation and in [1] for airborne sound insulation, field results or rather the modified field results can depend on the national special rules.

It would be a great advantage, if the rules and procedures could be further clarified in the international standards and thus harmonized between countries.

## 4 Discussion impact sound insulation requirements and special rules

In addition to the before-mentioned special rules, there might be other national special rules related to impact sound limits. It is of course also relevant and probably even more important to review descriptors and limit values, cf. Table 2. Furthermore, there are differences in requirements between countries depending on the type of living accommodation, dwellings for elderly, normal dwellings etc. It is important to notice that while the original INSTA proposal for a Nordic classification scheme only included dwellings, Finland, Norway, Sweden now have sound classification standards that includes various types of buildings, and Iceland is expected to implement a similar standard in 2010.

In spite of different building practices, there seems to be no scientific reason for various national requirements and special rules, since people in the Nordic countries are considered to have approximately the same living habits and equal expectations of their home environment. The reason is rather lack of cooperation during the last decade.

Complaints from residents in light-weight housing indicate a need to include lower frequencies in the evaluation for such construction types. Low frequencies in light weight structures might cause new disturbances from vibrations, implying a need to also developing regulations for vibrations.

### 4.1 Benefits of reviewing impact sound insulation descriptors, limits and rules

More work on the findings stated in this paper, cooperation and implementation would have the following benefits:

1. Increased exchange of knowledge – better understanding regarding the basis for national special rules
2. Less complicated national adaptations - some adaptations might be unnecessary with regard to subjective response
3. Facilitate and encourage more cross country trade between the Nordic countries
4. Lower costs for the building industry
5. Less risk for mistakes due to the fact that some special rules may not be discovered by consultants

The need for some of the special rules may be caused by a non-optimal choice of descriptors. Thus, it is important to understand the reasons and to investigate if other descriptors are more optimal.

The building industry today is not national any more. Almost all building companies and manufacturers are working at least on the Nordic market. Each company makes their own investigations and expensive, national adaptations in order to enter the market or to market new products. Besides, if the national adaptations are not discovered when transferring building systems or building products from one country to another, the costs will raise even more afterwards. Often, it is necessary to involve consultants from each country in order to understand and clarify the differences for the developer.

Previous studies and the development in Europe [24-28] as well as the revision of ISO 717 [29-30] seem to indicate that instead of the present  $L'_{n,w}$  as the basic descriptor for impact sound insulation limits in the Nordic countries, the preferred, descriptor could be  $L'_{nT,w}$  combined with a low-frequency adaptation term. In Finland, a report about uncertainties of low-frequency  $y$  measurement has been published [21].

## 4.2 Reviving the Nordic cooperation?

There is a lot more to do until the differences between the sound insulation requirements and classification schemes in the Nordic countries are fully described. However, this paper and the corresponding paper describing airborne sound insulation might be used as a first basis in order to identify the main differences in descriptors, limits and rules. It would be of great benefit to sort out unnecessary additional rules and keep special rules to a minimum.

In a revived Nordic cooperation the most important rules could be identified and other differences discussed. There should also be a close cooperation with the Baltic countries, because their regulations to a wide extent are inspired by the Nordic countries. Part of the work could be done in the Swedish-Danish Interreg IV project Silent Spaces [31].

The results of revived Nordic cooperation could provide input for revision of ISO 717 [29-30], and for cooperation in COST Action TU0901 [32] aiming at harmonization of descriptors and classification schemes in Europe.

## 5 Summary

This paper is summarizing national special rules for impact sound insulation requirements in the building regulations in the Nordic countries and is coordinated with a corresponding paper about airborne sound insulation [1].

Nordic countries were rather close to meet an agreement in the mid 90's. However, lack of consensus and the asynchronous revisions of building regulations led to stop of cooperation soon after. Since then, differences between the Nordic countries have increased. Descriptors and other rules differ more than what is obvious at the first glance, when comparing the regulations or classification standards. When comparing the diversified requirements and standards existing now - about 15 years after- it seems to be time to reconsider the situation and reopen cooperation to the benefit of the residents of dwellings, building industry and development of building constructions. The largest differences in requirements and classes are found for impact sound insulation. The present situation impedes development and creates trade barriers, and there seems to be a high interest for all parties involved in the building process to change the situation.

It is concluded that a revived Nordic cooperation could contribute to identify the most important special rules, and it is proposed to prepare a common Nordic document with an overview of all national building acoustic requirements and classes in the Nordic countries, starting with dwellings. The results of such work, parts of which could be done in the Interreg IV project Silent Spaces [31], could provide useful input for the revision of ISO 717 [29-30], and for the work within the COST Action TU 0901 [32] aiming at harmonization of descriptors and classification schemes in Europe.

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