How to translate existing airborne sound insulation descriptors to future proposals

Carolina Monteiro[1], María Machimbarrena [1],Ana Isabel Tarrero [1],Reine Johansson[2]

[1]Applyed Physics Department, Universidad de Valladolid, Valladolid, Spain
[2]INTECO -International Technology Consulting, Uddevalla, Sweden
(carolarqurb@gmail.com)

Abstract

In the near future, a common acoustic classification scheme for dwellings in Europe might become a reality, supported by ISO/NP 19488 proposal. In this future scenario, most countries will need to estimate what their actual sound insulation requirements would be if translated to a new descriptor. This paper investigates how the translation of airborne sound insulation descriptors could be done based on the analysis of a very large set of airborne sound insulation measurements performed in situ. The results of this study show that it is possible to make very good translations between most descriptors for heavyweight walls but for lightweight walls the exiting descriptors show a lower correlation to new ones.

Keywords: sound insulation translation, acoustic classification scheme

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1 Introduction

In the field of building acoustics, national regulations are in charge of citizen protection, but there is a growing demand by inhabitants for higher acoustic performance in order to obtain better levels of acoustic comfort. Sound insulation classifications schemes define acoustic classes according to different levels of sound insulation. In several European are countries they are being developed, or already exist, and due to the lack of coordination among them, *a significant diversity in terms of descriptors, number of classes, and class intervals occurred between national schemes* [1].

A European acoustic classification scheme with a number of quality classes was proposed within COST Action TU0901 European research and networking project [2], where 32 countries participated. Due to the existing high degree of diversity of regulatory requirements and descriptors [3,4], the proposed classification scheme was based in a set of harmonized descriptors for airborne and impact sound insulation also proposed by the same action. . Due to the interest of this initiative, the proposal has been used as preliminary draft for ISO/NP 19488 [5]

However, there was no consensus among participant countries and the proposal [6] was cancelled, at least until more conclusive research is done in the field to enlighten its main controversial topics. The debate is still open and relevant research is being done on different topics such as measurement procedures at low frequencies topics [7], effect of low frequency inclusion on measurement uncertainty assessment ratings [8–10] and subjective/objective aspects of sound insulation descriptors [11–14], just to mention some of the most recent studies related to the harmonization of sound insulation descriptors.

Given the difficulty found in coming to a perfect agreement on harmonized descriptors, the COST TU0901 Acoustic Classification scheme for dwellings proposal, was designed using most agreed descriptors and preliminary proposing a frequency range assessment from 50 Hz. For airborne sound insulation the selected descriptors were $D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$ and/or $D_{nT,100} = D_{nT,w} + C_{100\text{-}3150}$.

Table 1 presents the COST Action TU0901 classification scheme proposal. Advantages and justification for this proposal, including frequency range and assessment methods can be found in [2,6]. Due to the interest of this initiative, the proposal has been used as a draft input for a new ISO project ISO/NP 19488 – Acoustic Classification Scheme for Dwellings [5]

Type of space	Class A $D_{nT,50}$ (dB)	Class B $D_{nT,50}$ (dB)	Class C $D_{nT,50}$ (dB)	Class D $D_{nT,50}$ (dB)	Class E $D_{nT,50}$ (dB)	Class F $D_{nT,50}$ (dB)
Between a dwelling and premises with noisy activities (3)	≥ 68	≥ 64	≥ 60	≥ 56	≥ 52	≥ 48
Between a dwelling and other dwellings and rooms outside the dwelling	≥ 62	≥ 58	≥ 54	≥ 50	≥ 46	≥ 42

NOTES

(1) $D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$;

(2) As an alternative to $D_{nT,50}$, the performance can be estimated for all types of construction by the currently more common descriptor $D_{nT,100} = D_{nT,w} + C$, see clause 3. If $D_{nT,100}$ is applied, the class denotation is X_{100}, eg. B_{100}.

(3) Premises with noisy activities are rooms for shared services like laundries, central boiler house, joint/commercial kitchens or commercial premises like shops, workshops or cafés. However, in each case, noise levels must be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques etc. Offices are normally not considered as noisy premises, and the same criteria as for dwellings apply.

Figure 1 – class criteria for airborne sound insulation as proposed by COST TU0901. From Chapter 5 of [2]

The correlation and corresponding translation between different airborne sound insulation descriptors was object of study in the COST TU0901 project [15–17] . Gerretsen and Dunbavin [17] present two different proposals, one based on basic building acoustics equations and the other using a statistical method, which is the approach presented in this paper. Only few lightweight walls were included in this previous studies and this study points out the need of studying the problem further since the translation depends strongly on the building type.

2 Objectives

This study aims at providing valuable evidence for the “airborne sound insulation descriptors translation procedure”, based on a large set of in situ measurements. Most European airborne sound insulation descriptors and requirements have been translated into the proposed harmonized ones ($D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$ and $D_{nT,100} = D_{nT,w} + C_{100\text{-}3150}$).

The main objectives of the paper can then be summarized as follows:

- Based on a large set of in situ airborne sound insulation measurements, to propose updated translation equations between existing airborne sound insulation descriptors and proposed ones $D_{nT,50}$ and $D_{nT,100}$.
- To compare the obtained translation equations with those proposed by Gerretsen in [17,18].
- To investigate translation effects for heavy and light weight walls.

3 Data set description

The input data consisted on a set of 1.099 field airborne sound insulation measurements of 9 different types of separating walls (7 heavy y 2 lightweight). All walls were constructed in the United Kingdom in compliance with the relevant Robust Details [19] specifications. Testing and on-site inspections were carried out on a sample of structures in dwellings under construction to ensure compliance with the construction system by workmanship and with UK Building Regulations.

In Table 2 some statistical parameters are given for the complete set of walls. In tables 3 and 4 some statistical parameters are presented for heavyweight and light weight walls separately. The construction system of the seven types of heavyweight walls (from 1 HW to 7 HW) and the two types of lightweight walls (1 LW and 2 LW) is summarized in Tables 4,5 and 6.

Table 1 – Data set information

Set of all walls	
Average $D_{nT,50}$	57,97
Standard deviation	3,94
No of samples	1.099

Table 2: heavyweight walls data set information.

Heavy walls	**Total**	**1 HW**	**2 HW**	**3 HW**	**4HW**	**5 HW**	**6HW**	**7 HW**
Average DnT,50	57,80	57,45	57,40	58,75	57,40	59,30	56,15	57,00
Standard deviation	4,10	3,70	3,85	4,45	4,00	4,20	3,75	2,70
No of samples	654	53	63	110	337	69	13	9

Table 3: light weight walls data set information.

Lightweight walls	Total	1 LW	2 LW
Average $D_{nT,50}$	58,10	58,25	57,90
Standard deviation	3,60	3,50	3,80
No of samples	445	245	200

Table 4: construction system of plaster finished heavyweight walls.

<table>
<tr><td colspan="2">Heavyweight walls</td></tr>
<tr><td>Plaster finisehd walls</td><td>Wall finish : 13mm plaster or cement both sides</td></tr>
<tr><td colspan="2">1 HW
• Dense aggregate Block (1850 to 2300 Kg/m3)
• Cavity width 75mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
<tr><td colspan="2">2 HW
• Light weight aggregate Block (1350 to 1600 Kg/m3)
• Cavity width 75mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
<tr><td colspan="2">3 HW
• Light weight aggregate Block (1850 to 2300 Kg/m3)
• Cavity width 100mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
</table>

Table 5: construction system of of gypsum board finished heavyweight walls

<table>
<tr><td colspan="2">Heavyweight walls</td></tr>
<tr><td>Gypsun board finished walls</td><td>Wall finish : gypsum-based board mounted on dabs on cement</td></tr>
<tr><td colspan="2">4 HW
• Dense aggregate Block (1850 to 2300 Kg/m3)
• Cavity width 75mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
<tr><td colspan="2">5 HW
• Light weight aggregate Block (1350 to 1600 Kg/m3)
• Cavity width 75mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
<tr><td colspan="2">6 HW
• Light weight aggregate, or Hollow or cellular blocks (1350 to 1600 Kg/m3)
• Cavity width 100mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
<tr><td colspan="2">7 HW
• Light weight load bearing blocks (1050 Kg/m3)
• Cavity width 75mm (min)
• Block thickness 100mm (min), each leaf</td></tr>
</table>

Table 6: construction system of lightweight walls.

Light weight walls
1 LW • 240mm (min) between inner faces of wall linings. 50mm (min) gap between studs • Wall lining: 2 or more layers of gypsum-based board (total nominal mass per unit area 22 kg/m^2), both sides • 60mm (min) mineral wool material batts or quilt (density 10 – 60 kg/m^3) both sides.
2 LW • 240mm (min) between inner faces of wall linings. 50mm (min) gap between studs • Wall lining: 2 or more layers of gypsum-based board (total nominal mass per unit area 22 kg/m^2), both sides • Sheathing: 9mm (min) thick board • 60mm (min) mineral wool material batts or quilt (density 10 – 60 kg/m^3) both sides.

4 Translation of most commonly used single number descriptors of airborne sound insulation into $D_{nT,50}$ / $D_{nT,100}$

As explained by Gerretsen and Dubvain [17,18], the translation between different sound insulation descriptors is not an easy task and seems to depend on the type of building. In this paper a statistical approach was used to obtain the relation between existent descriptors and the ones proposed in ISO/NP 19488, $D_{nT,50}$ / $D_{nT,100}$.

Calculations were performed according to the following steps:

- Using the complete set of in situ airborne sound insulation measurements (1.099), the seven most adopted single number descriptors for airborne sound insulation around Europe [7] were calculated (that is R'_w ; $R'_w + C$; $R'_w + C_{(50\text{-}3150Hz)}$; $D_{nT,w}$; $D_{nT,w} + C_{tr}$; $D_{nT,w} + C$; $D_{nT,A\ (100\text{-}5KHz)}$.
- $D_{nT,50}$ and $D_{nT,100}$ were also calculated.
- Pearson correlation coefficient between $D_{nT,50}$ / $D_{nT,100}$ and the most used airborne sound insulation descriptors was calculated. Results are presented in Table 7 classified in “heavy” and “light”, for those tests were the common partition was a heavyweight or lightweight wall respectively.
- Finally, a scatter plot and a simple linear regression between $D_{nT,50}$ / $D_{nT,100}$ and each of the previously selected descriptors were made. These linear regressions are what hereinafter will be referred to as “translation equations” between each pair of descriptors.

Table 7: Pearson correlation coefficient between existent descriptors and new ones.

(y) \ (x)		**R'w**	**R'w + C**	**R'w + C (50-3150Hz)**	**DnT,w**	**DnT,w + Ctr**	**DnT,w + C**	**DnT,A (100-5KHz)**
DnT,50	**All**	0,74	0,78	0,90	0,81	0,87	0,87	0,86
	Heavy	0,89	0,90	0,91	0,96	0,95	0,98	0,98
	Light	0,60	0,66	0,89	0,70	0,72	0,76	0,76
DnT,100	**All**	0,90	0,92	0,78	0,97	0,93	1,00	1,00
	Heavy	0,91	0,92	0,89	0,99	0,96	1,00	1,00
	Light	0,84	0,89	0,68	0,94	0,93	1,00	1,00

Table 8: Translation equations between descriptors for the categorized data.

(x) \ (y)	**Type of Walls**	**DnT,50**	**DnT,100**
R'w	**Heavy**	y = 0,82x + 9,95	y = 0,87x + 7,54
	Light	y = 0,58x + 22,00	y = 0,81x + 11,17
R'w + C	**Heavy**	y = 0,85x + 9,25	y = 0,91x + 7,07
	Light	y = 0,64x + 19,89	y = 0,86x + 9,96
R'w + C (50-3150Hz)	**Heavy**	y = 0,90x + 7,32	y = 0,92x + 7,09
	Light	y = 0,88x + 8,59	y = 0,67x + 23,67
DnT,w	**Heavy**	y = 0,89x + 4,74	y = 0,95x + 2,06
	Light	y = 0,70x + 13,57	y = 0,95x + 1,51
DnT,w + Ctr	**Heavy**	y = 0,97x + 6,03	y = x + 4,52
	Light	y = 0,69x + 19,99	y = 0,89x + 12,62
DnT,w + C	**Heavy**	y = 0,94x + 3,73	y = x + 1,13
	Light	y = 0,76x + 12,13	y = x + 1,34
DnT,A (100-5KHz)	**Heavy**	y = 0,94x + 2,97	y = x + 0,23
	Light	y = 0,76x + 11,32	y = x + 0,17

Analyzing Tables 7 and 8, it is possible to observe that the translation between descriptors is not independent on the building type. It is noticeable that in Table 7 the Pearson correlation coefficients both for $D_{nT,50}$ and $D_{nT,100}$ for heavy walls are above 0.89 for all descriptors whereas for lightweight walls there are values starting at 0.6. This means that for lightweight walls the spread of the data around the lineal regression equation will be wider than for heavyweight walls. For the translation into $D_{nT,100}$ it is interesting to point out that, both the Pearson correlation coefficient (Table 7) and the corresponding equations (Table 8) show that the building type effect is not so important when performing the translation. On the other hand, in Table 8 it is possible to observe that, apart from for $R'_w + C_{(50\text{-}3150Hz)}$, there is a significant difference between the resulting translation equations for heavy/light weight solutions when $D_{nT,50}$ is considered.

Since one of the main objectives of this paper is to propose updated translation equations between existing airborne sound insulation descriptors and proposed ones $D_{nT,50}$ and $D_{nT,100}$, it is necessary to evaluate whether it is reasonable to adopt the equations proposed by Gerretsen in [17] or if a different pair of translating equations should be considered depending on the building type.

4.1 Comparison between different translation proposals

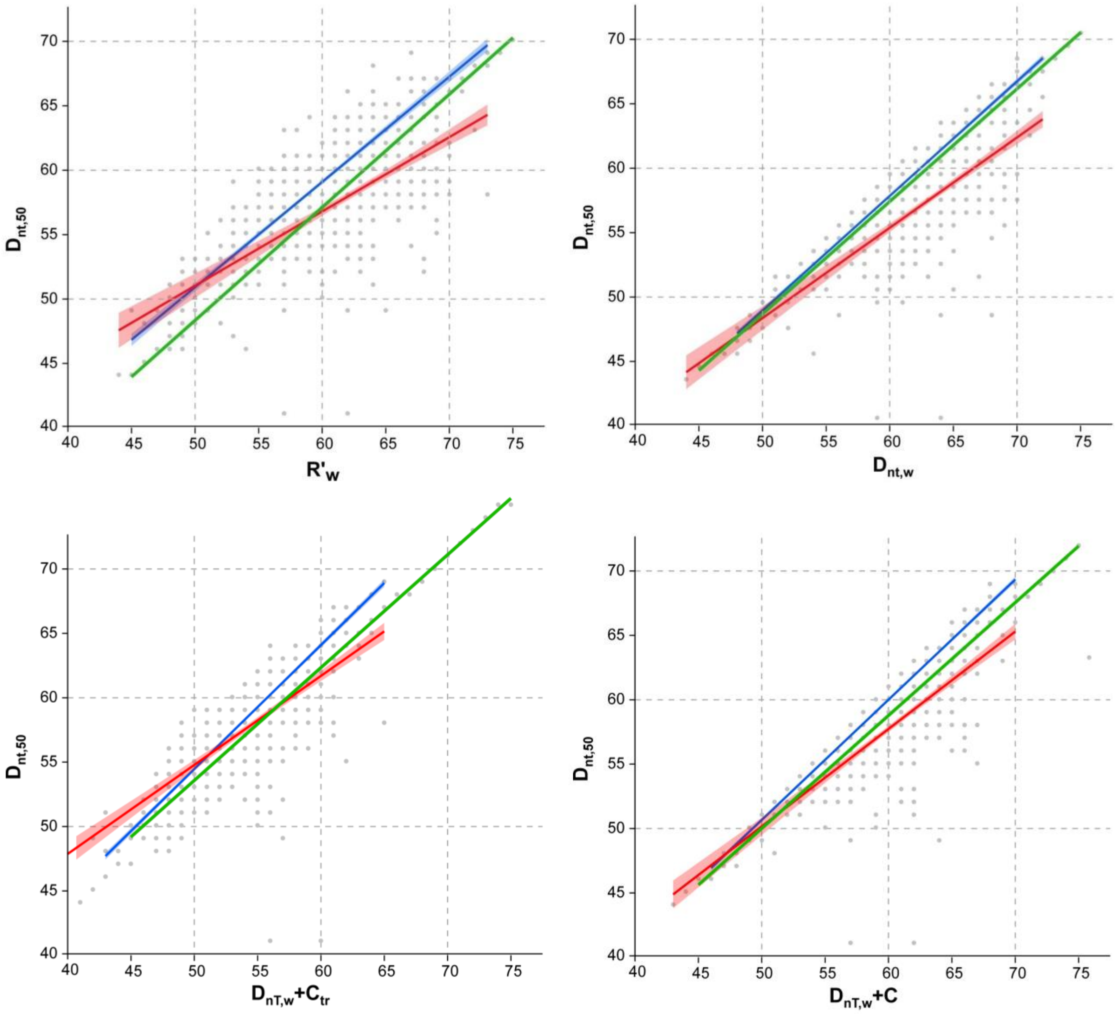

Figure 2 – comparison of translation methods

In the plots of Figure 2 it is possible to observe the comparison of three different proposed translation equations between four commonly used descriptors and $D_{nT,50}$.. No plots were made for the translations to $D_{nT,100}$,as according to the data presented in Tables 7 and 8 , there are no significant difference related to the building type. In Figure 2 plots:

- Solid red line represents the lineal regression correspondent to the translation equation based on heavyweight walls data;
- Solid blue line represents the lineal regression correspondent to the translation equation based on lightweight walls data;
- Solid green line represents the results obtained by the translation equation proposed by Gerretsen for a range from 45dB to 75dB of the existent sound insulation descriptor (x axis);
- Blue and red shaded areas correspond to de 95% confidence band.

For the data set presented in this study, it is possible to observe in Figure 2 that:

- Heavy and light weight walls data based translations are not coincident for almost any value of the four existent airborne sound insulation descriptor, expect those around 50dB where it seems that heavy and light weight walls based translation methods coincide;

- In all plots The 95% confidence band is wider for the lowest values of airborne sound insulation of the data set, which indicates a higher variability;

- Gerretsen translation proposal approximates to heavyweight walls translation for those airborne sound insulation descriptors based on level difference. As expected, for the existent descriptor R'_w , the differences are higher as the mathematical method used by Gerretsen to obtain the equations makes use of assumptions valid only for heavyweight walls.

- The differences of the values of translated airborne sound insulation can exceed 5dB depending on the selected method.

5 Conclusions

The results of this study show that it is possible to make very good correlations/translations between most descriptors for heavyweight solutions although the correlation between existing descriptors and new indices improve if the assessment frequency range is the same in both cases. This is in agreement with the findings reported by COST TU0901. The statistical approach presented in this study results converge with the mathematical translation but clearly indicates the effect of the building system.

The spread of the obtained values of airborne sound insulation exceed 5dB depending on the method employed. Such spread need to be considered by building regulators of each country to see the practical consequences of a change towards a European classification scheme based on a harmonized set of descriptors.

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