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A comprehensive study for a classification scheme for dwellings in Brazil

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ABSTRACT

ABNT NBR 15575 was published in 2013 and establishes airborne and impact sound insulation criteria for residential buildings in Brazil. This standard presents three levels of performance - minimum (mandatory), intermediate, and superior - through an informative annex that classifies the acoustic

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performance for each requirement. Even after ten years of entering into force, the application of the standard is still not fully consolidated, although its application is mandatory under Brazilian law. This article proposes an Acoustic Classification Scheme (ACS) for airborne and impact sound insulation in dwellings, intending to enable non experts to understand acoustic performance quickly and intuitively. The proposed ACS is based on ISO/TS 19488:2021, which presents harmonized criteria for different acoustic requirements. A large database of field measurements of building systems, typical of Brazil and obtained in different regions, was analyzed to verify the distribution of samples using this new ACS. An A/B/C/D/E/F scale is proposed in the ACS as a reference for a new Brazilian standard, and results are presented for airborne and impact sound insulation in dwellings.

1. INTRODUCTION

In 2013, the Brazilian building performance standard ABNT NBR 15575 [1] entered into force. There were no standards or regulations for airborne and impact sound insulation in residential buildings in Brazil until the publication of ABNT NBR 15575. This document introduced new requirements and criteria for building performance in dwellings. The standard framework was based on the international standard ISO 6241:1984 [2].

Brazil is expected to experience a significant demand for new housing in the coming years, which has already increased over the past decade due to population growth and the formation of new families. According to Abrainc [3], this demand is estimated to reach 30.7 million new homes by 2030. Therefore, the definition of minimum acoustic requirements has had and will continue to have a significant impact on the acoustic quality of new housing construction.

The standard presents requirements for building performance, including acoustics, thermal, luminosity, and fire safety, among others. The acoustic section of the standard specifies requirements for sound insulation between dwellings, including airborne and impact sound insulation, as well as facade insulation. There are also optional requirements for noise from building services equipment and plumbing. The standard uses the descriptors and methods for acoustic tests indicated in ISO 16283, ISO 10052 and ISO 16032.

Although compliance with technical standards is optional in Brazil, the application of ABNT NBR 15575 is mandatory due to the Consumer Protection Code [4]. The requirements have become mandatory for all residential buildings designed after July 19th, 2013, but with no criteria established for existing housing or retrofit [5].

In the last decade, the enforcement of ABNT NBR 15575 has had a significant impact on residential construction in Brazil, from the development of new construction systems to the significant increase in the number of acoustic consulting firms and accredited laboratories for acoustic measurements [6].

The criteria for airborne and impact sound insulation practically have not changed since the publication of ABNT NBR 15575. The 2021 revision introduced an objective procedure for defining façade insulation criteria, based on sound measurements and simulation, which was previously subjective and problematic [5]. Additionally, the use of the ISO 12354 family of standards as the preferred calculation method was included.

Unfortunately, the requirements and criteria for acoustics can be very technical and difficult for many homebuyers to understand. To make this information more accessible, especially to end-users, this paper presents a comprehensive study on a classification scheme for dwellings in Brazil.

2. OBJECTIVES

The main objectives of this study are:

- Present a study for an ACS (Acoustic Classification Scheme) for dwellings, with a new range of classes for the building acoustics performance descriptors indicated in ABNT NBR 15575, based on previous proposal [5,6,7];
- Compare the current and the suggested criteria with the requirements presented on international document ISO TS 19488:2021 [8]
- Evaluate the percentage of buildings that meet each proposed class based on field measurements carried out in new dwellings. For this analysis, it was used a large database of field measurements performed after ABNT NBR 15575 implementation in 2013.
- Evaluate the results and the applicability of the ACS.

3. METHODOLOGY

Was proposed a ACS to be use in Brazil. As a starting point it was followed the framework proposed by ISO TS 19488:2021 [8], that indicates a classification scheme with six classes, based on harmonized criteria for some acoustic requirements. A scale of 4dB steps between classes was proposed, and "A-D" (new houses) and "E-F" (old houses) classes indicators were used to specify different levels of acoustic performance in dwellings. The "D" class always follows the same criteria of ABNT NBR 15575 to harmonize the new ACS with the mandatory values in Brazil.

To evaluate the potential impact of this ACS in Brazil, we used 'in situ' measurements obtained from 6,886 field measurements of newly constructed Brazilian dwellings. All the measurements were carried out in compliance with ISO series 16283 [9-11], with the frequency range from 100 Hz up to 3150 Hz. Data from building service equipment noise was obtained following ISO 16032:2004 procedures [12]. All the laboratories that carried out the sound measurements are accredited or in accreditation process, using data from July 19th, 2013, until February 2024. July 19th, 2013. The samples were distributed in four different regions in Brazil.

All descriptors presented in ABNT NBR 15575 consider the frequency range starting from 100 Hz up to 3150 Hz, thus no extended frequency range with low frequencies is considered. To make it possible to compare results, the descriptors and requirements presented on ISO TS 19488:2021 were converted to those adopted in Brazil using the procedure indicated.

Based on the field data, a percentage of compliance was obtained for each class of the proposed new ACS. The results of each requirement were analyzed briefly.

4. ACOUSTICAL CLASSIFICATION SCHEME (ACS)

The proposed ACS was summarized on Table 1. The underlined bold values are the minimum criteria for each requirement.

Table 1: ACS proposed

Requirement	Descriptor	Classes					
		A	B	C	D	E	F
Impact sound							
Impact sound pressure level in dwellings, from other dwellings	$L'_{nT,w}$ [dB]	≤ 56	57-64	65-72	73-**<u>80</u>**	81-84	85-88
Impact sound pressure level in dwellings from premises with noisy activities	$L'_{nT,w}$ [dB]	≤ 43	44-47	48-51	52-**<u>55</u>**	56-59	60-63
Aiborn sound insulation							
Airborne sound insulation between a dwelling and other dwellings - Living Rooms and Kitchens - none of the rooms is a bedroom [1]	$D_{nT,w}$ [dB]	≥52	51-48	47-44	43-**<u>40</u>**	39-36	35-32
Airborne sound insulation between a dwelling and other dwellings - At least one room is a bedroom [1]	$D_{nT,w}$ [dB]	≥57	56-53	52-49	48-**<u>45</u>**	44-41	40-37
Airborne sound insulation between a dwelling and premises with noisy activities	$D_{nT,w}$ [dB]	≥57	56-53	52-49	48-**<u>45</u>**	44-41	40-37
Facade sound insulation							
Facade sound insulation in dwellings	$D_{2m,nT,w}$ [dB]	$\geq L_{inc}$-28	$\geq L_{inc}$-32	$\geq L_{inc}$-36	$\geq L_{inc}$-**<u>40</u>**	$\geq L_{inc}$-44	$\geq L_{inc}$-48
Service equipment levels							
Equivalent sound levels in dwellings due to building service equipment	$L_{Aeq,nT}$ [dB]	≤ 25	26-29	30-33	34-**<u>37</u>**	38-41	42-45
Maximum Sound levels in dwellings due to building service equipment	$L_{ASmax,nT}$ [dB]	≤ 30	31-34	35-38	39-**<u>42</u>**	43-46	47-50

1. The element between dwellings can be a partition or a hall for this requirements.

5. RESULTS

The results of the percentage obtained of each class based on the measurements were presented on Table 2. The results were analyzed individually in the next section.

Table 2: ACS proposed, with the distribution of the classification based on measured results.

Requirement	Number of measurements [n]	Descriptor / distribution	Classes						NPD
			A	B	C	D	E	F	
Impact sound									
Impact sound pressure level in dwellings, from other dwellings	1529	$L'_{nT,w}$ [dB]	≤ 56	57-64	65-72	73-80	81-84	85-88	≥ 89
		%	9%	15%	20%	45%	10%	1%	0%
Impact sound pressure level in dwellings from premises with noisy activities	91	$L'_{nT,w}$ [dB]	≤ 43	44-47	48-51	52-55	56-59	60-63	≥64
		%	15%	9%	13%	15%	12%	12%	24%
Aiborn sound insulation									
Airborne sound insulation between a dwelling and other dwellings - Living Rooms and Kitchens - none of the rooms is a bedroom [1]	1239	$D_{nT,w}$ [dB]	≥52	51-48	47-44	43-40	39-36	35-32	≤ 31
		%	9%	22%	35%	29%	3%	1%	1%
Airborne sound insulation between a dwelling and other dwellings - At least one room is a bedroom [1]	2128	$D_{nT,w}$ [dB]	≥57	56-53	52-49	48-45	44-41	40-37	≤ 36
		%	8%	14%	24%	34%	15%	4%	1%
Airborne sound insulation between a dwelling and premises with noisy activities	187	$D_{nT,w}$ [dB]	≥57	56-53	52-49	48-45	44-41	40-37	≤ 36
		%	36%	32%	18%	9%	1%	0%	4%
Facade sound insulation									
Facade sound insulation in dwellings	1497	$D_{2m,nT,w}$ [dB]	≥L_{inc}-28	≥L_{inc}-32	≥L_{inc}-36	≥L_{inc}-40	≥L_{inc}-44	≥L_{inc}-48	≥L_{inc}-49
		%	20%	24%	33%	20%	3%	0%	0%
Service equipment levels									
Equivalent sound levels in dwellings due to building service equipment	126	$L_{Aeq,nT}$ [dB]	≤ 25	26-29	30-33	34-37	38-41	42-45	≥ 46
		%	7%	21%	25%	30%	7%	4%	6%
Maximum Sound levels in dwellings due to building service equipment	89	$L_{ASmax,nT}$ [dB]	≤ 30	31-34	35-38	39-42	43-46	47-50	≥ 51
		%	18%	16%	17%	23%	17%	1%	8%

1. The element between dwellings can be a partition or a hall for this requirements.

The information for each requirement of the proposed Brazilian ACS was graphically organized as shown in Figures 1 to 9, as follows:

- 1st line presents a scale, in dB, to guide the comparison;
- 2nd line presents the classification presented by ABNT NBR 15575:2021 [7];
- 3rd line presents the proposal for a Brazilians ACS;
- 4th line presents the percentage and classification of measured data from Brazilian buildings and the number of sound measurements considered (n);

– 5th line presents adapted ISO TS 19488:2021 ACS requirements. The adaptation was carried out to make the requirements comparison possible.

5.1 Impact sound pressure level in dwellings, from other dwellings

The ABNT NBR 15575 requirement has the lowest criteria when compared to the criteria proposed by ISO TS 19488, with a difference of 22dB.

The values measured mostly refer to concrete slabs, with or without plaster lining, which are easy to install and do not involve any major complexities in the construction system adopted. These two aspects may justify the high result obtained, with 89% at least meeting the minimum.

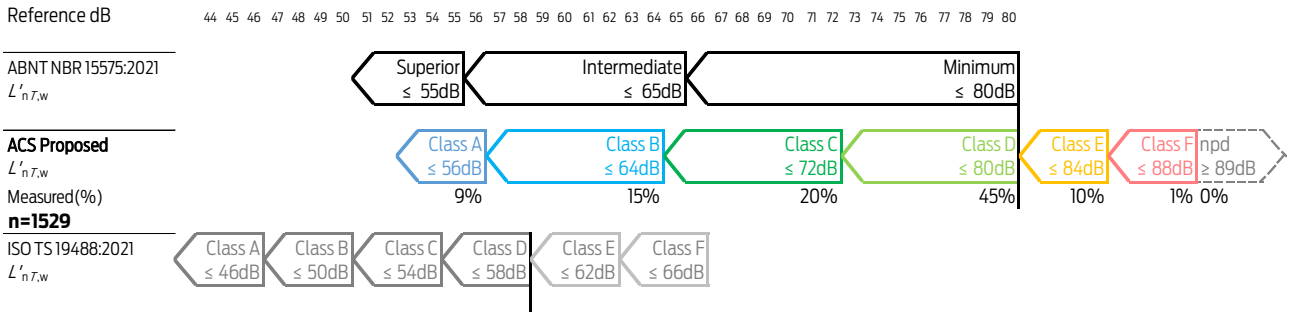


Figure 1 - Impact sound pressure level in dwellings, from other dwellings

5.2 Impact sound pressure level in dwellings from premises with noisy activities

The minimum values of ABNT NBR 15575 and ISO TS 19488 for this criteria are very close, differing by only 3dB.

Meeting this criteria typically requires the use of floating floors, special coatings, or more complex systems, which are innovative in the Brazilian construction process and more susceptible to execution problems.

This may be a contributing factor to the low compliance rate of at least the minimum criterion (52%).

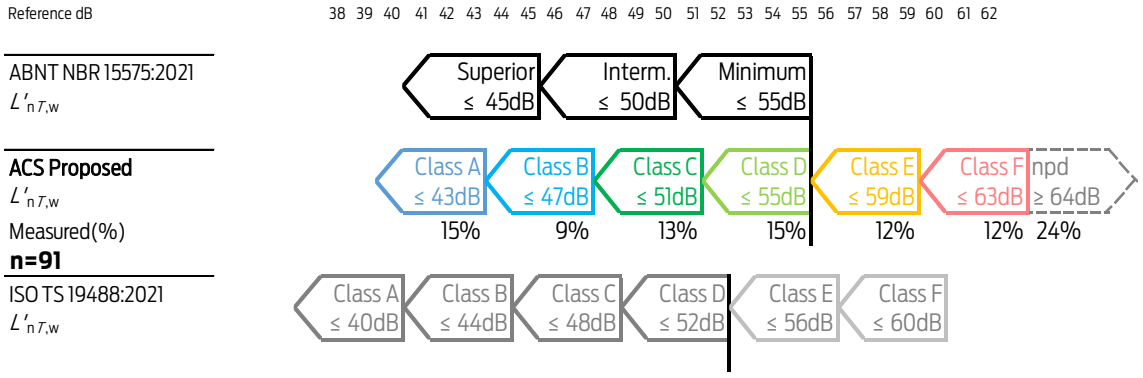


Figure 2 - Impact sound pressure level in dwellings from premises with noisy activities

5.3 Airborne sound insulation between a dwelling and other dwellings - Living Rooms and Kitchens

In ABNT NBR 15575 there are two main criteria for airborne sound insulation between dwellings. In this requirement, the criteria are used for airborne sound insulation between dwellings without bedrooms. In Brazil, heavy weight systems such as concrete and ceramic block walls and concrete slabs are widely used, meeting easily the criteria of up to 40dB, with 94% meeting at least the minimum.

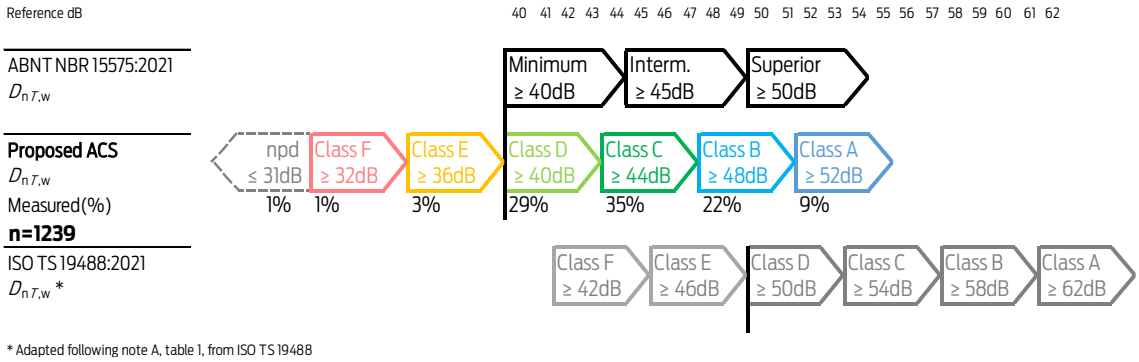


Figure 3 - Airborne sound insulation between a dwelling and other dwellings - Living Rooms and Kitchens

5.4 Airborne sound insulation between a dwelling and other dwellings - At least one room is a bedroom

ABNT NBR 15575 has a higher requirement for partitions (5dB higher) where at least one of the rooms is a bedroom. On the other hand, the criterion is 5dB lower than that proposed by ISO TS 19488.

Compliance with at least the minimum of 80% was observed. A 14% reduction in compliance was observed when compared to the criteria where there is no bedroom.

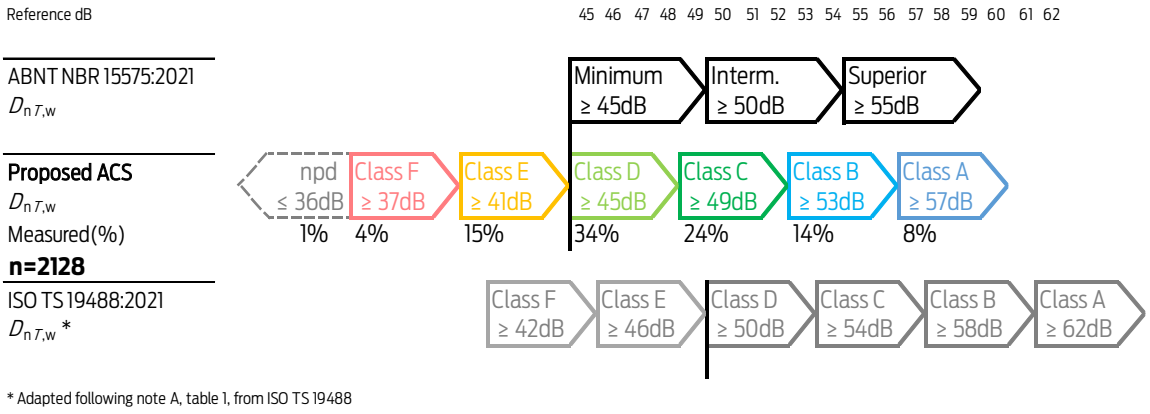


Figure 4 - Airborne sound insulation between a dwelling and other dwellings - At least one room is a bedroom

5.5 Airborne sound insulation between a dwelling and premises with noisy activities

The compliance rate for meeting at least the minimum requirements of ABNT NBR15575 was 95%. This criteria typically applies to common areas. In the samples studied, most common areas were located on different floors within the same dwellings, with a heavy weight system (concrete slabs) as the separating element. This characteristic may explain the 15% increase in compliance compared to the requirement where at least one of the rooms is a bedroom.

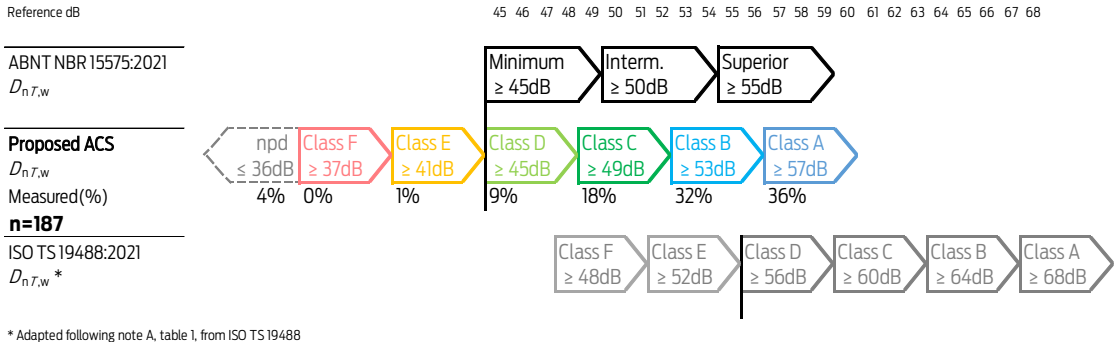


Figure 5 - Airborne sound insulation between a dwelling and premises with noisy activities

5.6 Facade sound insulation in dwellings

To determine the criteria for façade insulation, it is necessary to calculate the incident sound level on the housing unit's facade, Linc. This sound pressure level is used as the estimated long-term value Ld or Ln, and the highest level should be considered. Based on this value, the criteria are defined in a table.

Each housing unit's facade may have different Linc, even if they are built in the same building. To enable classification and comparison, a hypothetical Linc of 65dB was adopted for all unit facades in this analysis. In this scenario, at least the minimum performance level is met by 71% of the rooms in the analyzed sample.

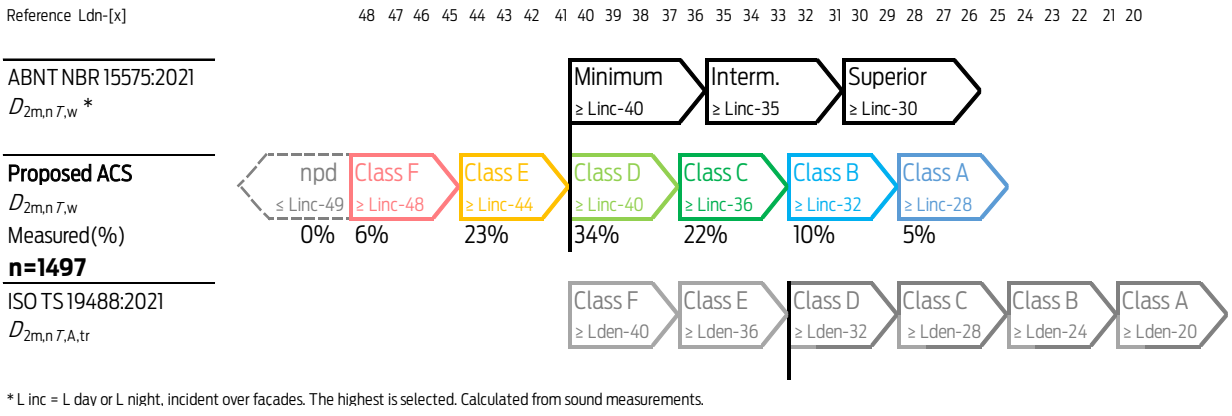


Figure 6 - Facade sound insulation in dwellings, for L_{inc}=65dB

5.7 Equivalent sound levels in dwellings due to building service equipment

The study found a smaller number of samples possibly due to the optional adoption of these criteria in ABNT NBR 15575. The compliance rate to the minimum was at least 83%. The ABNT NBR 15575 criterion is 3dB lower than the minimum proposed by ISO TS 19488.

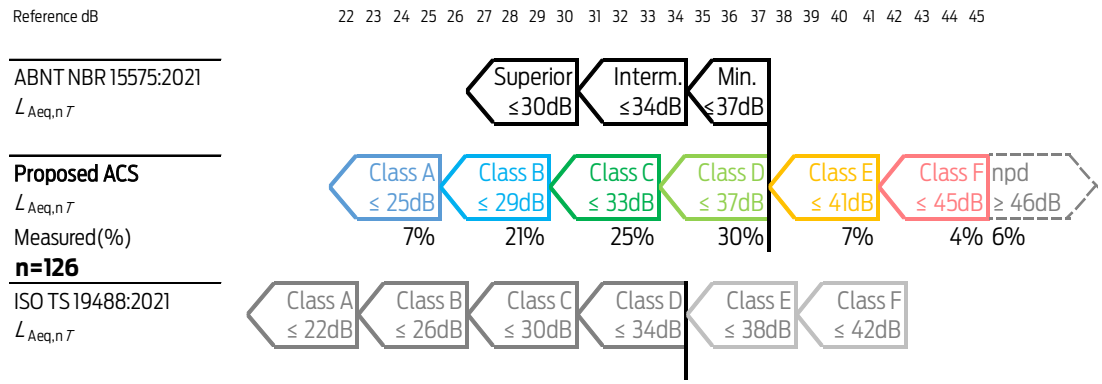
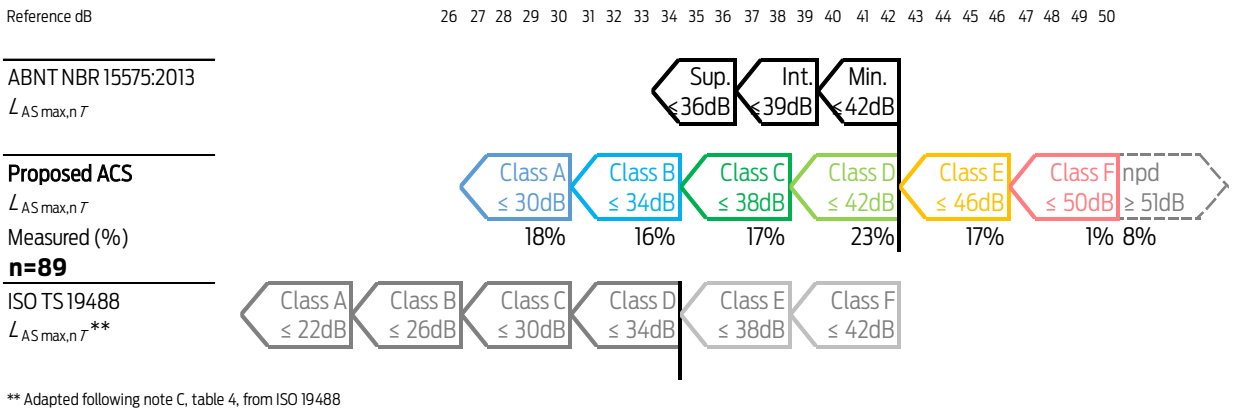


Figure 7 - Equivalent sound levels in dwellings due to building service equipment

5.8 Maximum Sound levels in dwellings due to building service equipment

As with the previous requirement, these criteria are optional in ABNT NBR 15575. The study may have used a smaller number of samples due to this reason. The compliance rate was at least 75%. It is worth noting that the ABNT NBR 15575 criterion is 8dB lower than the minimum proposed by ISO TS 19488.



** Adapted following note C, table 4, from ISO 19488

Figure 8 - Maximum Sound levels in dwellings due to building service equipment

6 CONCLUSIONS AND FUTURE WORK

Creating a system to facilitate public understanding of acoustic requirements would promote wider knowledge of the classification system, enabling users to compare performance when purchasing dwellings. This system is already in use in other countries [12].

The ACS presented here considers the same minimum mandatory criteria as indicated in ABNT NBR 15575, (minimum class D), to facilitate the implementation of the ACS. Criteria for new buildings are divided into four classes (A/B/C/D), while two additional classes (E/F) are proposed for older buildings and retrofits.

The presented approach aims to gradually increase the criteria proposed in ABNT NBR 15575. This allows for the assimilation of economic impact and technical challenges over time, with optimizations in the construction process using industrialized systems and workforce qualification.

The requirement for impact noise sound insulation has more unfavorable criteria compared to ISO TS 19488 (22dB). It is highly recommended to adopt a strategy to improve these values as soon as possible. Figure 9 presents a proposal for a gradual improvement in two steps, which would make it possible to reduce the gap from 22dB to 6dB when comparing the Brazilian future criteria proposed and ISO TS 19488.

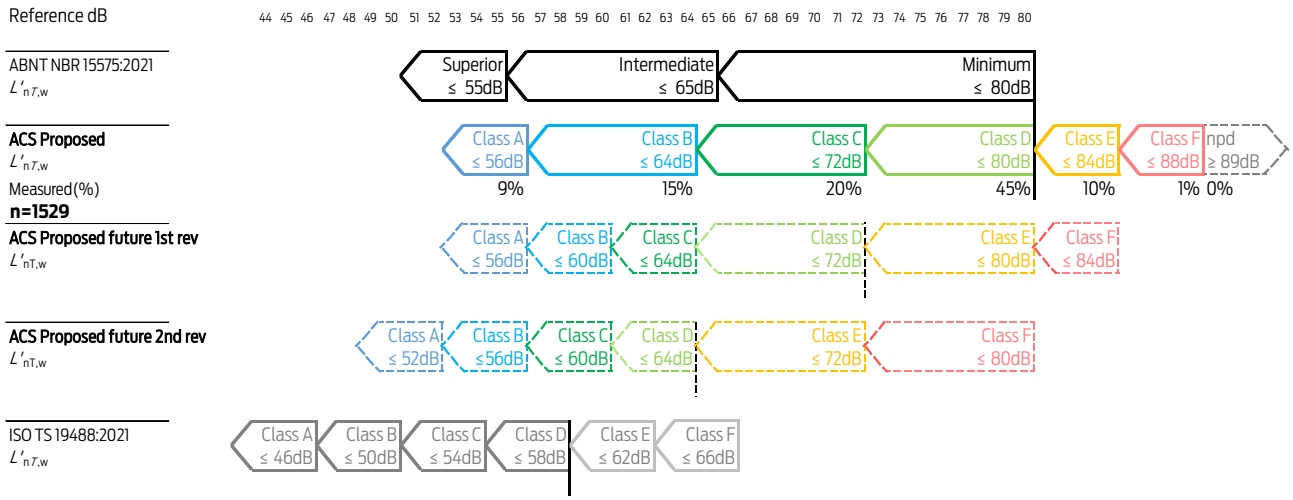


Figure 9 – Proposal for future revision for Impact sound pressure level in dwellings, from other dwellings

The subjective response of the Brazilian population to the criteria proposed in ABNT NBR 15575:2013 is currently unknown. Further research is needed to determine how Brazilians evaluate these criteria, which can guide proposals for increasing the requirement criteria where the assessment is more critical. This approach has been systematically implemented in other countries [13].

The establishment of an Brazilian ACS aligned to the ISO TS 19488 would facilitate the interchange of information and awareness among users, researchers and manufacturers throughout the world.

The findings outlined in this paper are limited to the dataset used and should not be generalized to the broader Brazilian construction market.

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