Proceedings of 20th International Congress on Acoustics, ICA 2010

23-27 August 2010, Sydney, Australia

The new Brazilian standard for performance in residential buildings

Stelamaris Rolla Bertoli (1) and Maria de Fatima Ferreira Neto (2)

School of Civil Engineering and Architecture - University of Campinas (UNICAMP), Brazil
PO Box 6021, 13.083-970
Campinas / SP – Brazil

(1) rolla@fec.unicamp.br
(2) neto.fis@hotmail.com

PACS: 43.15.+S

ABSTRACT

The recently published standard for performance in buildings, *NBR 15575 Residential buildings up to five storied – Performance*, approved in May 2008 and to be active from May 2010, presents among other items, acoustic performance for residential buildings up to five stories. Brazil is different from other Latin American countries that already had specific standards aimed at the acoustic performance in buildings, such as Argentina and Chile. Until then, Brazil has not had a document which defines criteria for residential buildings to submit best living conditions and use. This paper presents the structure and criteria of the new Brazilian standard to acoustical performance in buildings, the importance of the criteria for improving the quality of life of users of residential buildings. This work also provides a brief comparison of the Brazilian criteria with the criteria of other countries.

INTRODUCTION

The community's life is difficult and requires restriction of behavior, the need to respect social rules for good living in family, work, neighborhood and building it inhabits. Respect and obedience to social rules and boundaries are sometimes difficult to obtain and, in such cases, there may be conflicts between neighbors who do not infrequently extend to legal proceedings.

In the community, a major reason for conflicts between neighbors is just noise. In Australia, for example, there is a booklet that guides on how to deal with the noise of the neighbor. The first step to take if you have a noisy neighbor is to resort to dialogue (Australia, 2006). At this time, it puts into practice the citizenship, common sense and good neighborhood policy. If it does not work, this booklet shows the contacts of the bodies responsible for each type of complaint.

The establishment of limits or criteria for noise is not an easy task because each individual has his own limit of tolerance to noise, making it impossible to attend everyone individually and, additionally, the range of tolerance limiting, from nice noise until the noise that causes annoyance, it would be large.

For a person, the level of noise, in a certain moment of the day, may not be as troublesome as to another. For this reason, the community has to establish its limits for level of noise, based on culture and lifestyle. The emergence of standards and criteria to comfort noise is a consequence of the need for such limits. The definition of the criteria, according to Lalli (1988), has statistical character; a compliance with a criterion attends a statistical average of those involved.

This paper presents the acoustic performance criteria of the new Brazilian Standard from Associação Brasileira de Normas Técnicas – ABNT (Brazilian Association of Technical Standards), which will be active on May 12, 2010, NBR 15575 (ABNT, 2008). It presents also the legislation and regulations in force until then and international criteria for comparison with the Brazilian criteria.

PERFORMANCE *VERSUS* COMFORT

Specifically dealing with housing units, the users want to be able to enjoy their homes while they have their privacy preserved. The relationship between users in residential buildings can be peaceful if there is, first of all, mutual respect and obedience to the criteria of noise. Users and residents of buildings do not have as prime concern the physical aspects of noise that causes them discomfort or value of the insulation those partitions provide. The main concern of users is directed to the noise that is within their home, so that it matches their expectations of comfort and privacy (Barry, 2005).

With so many different activities to be held in a building, if they coincide with two or more antagonistic purposes, such as children's games and reading, which is not uncommon, however, it is part of day-to-day, good insulation of buildings is necessary. According to Barry (2005), an enclosure of a building should provide the user comfort and privacy befit-

ting the purpose of the acoustic environment, especially when intended for the home or intellectual work.

Although the nuisance caused by noise is not a recent problem, the concern with the proper sound insulation in residential buildings is relatively recent, when thinking about the history of construction, but not in terms of urban agglomeration. The Figure 1 represents the image of Direita Street, in downtown Sao Paulo, Brazil in 1916. The movement of vehicles and people on the streets and buildings of the time, very close to each other and with many windows, indicates that the noise was already present in the life of the citizen, and possibly was producing discomfort.

Source: Associação dos Engenheiros Ferroviários no Estado de São Paulo. <http://www.assef.com.br/sao_paulo_antiga.htm>
Figure 1: Direita street, São Paulo, in 1916.

At that time, São Paulo was not a city different from others of the same size. The life in the city and its own growth produced noise and discomfort. Only in 1929, with the advent of the acoustic magazine known as JASA (The American Journal of Acoustical Society), one of the greatest sources of information in various areas of acoustics, the question of discomfort in buildings began to be treated by the scientific community. Already in the first issue of this magazine in 1929, Laird and Coye addressed the topic with the article *Psychological measurements of annoyance related to the pitch and loudness*.

Over the years, the subject was further treated by JASA, in other scientific journals and later appearing in various media without scientific character. In 2008, the acoustic discomfort in residential buildings was treated on the subject of the cover, this time for a magazine that is not scientific, but it has great coverage in Brazilian territory and reaches the lay people who can feel the discomfort caused by noise in their homes. The magazine *Veja São Paulo*, which covers issues from 2008 (Ed. April, 2008) and 2010 (Ed. April, 2010) are shown in Figure 2, presents that in vertical condominiums, the noise is one of the items that causes most discomfort. In the 2008 issue, according to lawyer and trustee Márcio Rachkorsky, this is one of the most difficult problems to solve because it is often difficult to identify where the noise comes from, because the noise can come from high heels and from parties in the apartment as well. In the 2162 issue of April 2010 the magazine *Veja Sao Paulo*, presented again the subject about the problems in condominium and discomfort caused by the upstairs neighbor and their noise.

Source: Editora Abril, 2008, 2010
Figure 2: Covers of the magazines Veja São Paulo, issue 2060 (14/05/2008 - left) and issue 2162 (28/04/2010 - right.).

On the cover of the 2008 issue of the magazine it is represented a summary of the results of noise sources that bother, confirming the conclusions made twenty years earlier by Utley and Buller (1988) where they said that the barking of dogs is a grievance and a reason for discussions between the neighbors.

Other works have been published to show how much noise from the neighborhood causes discomfort, and sometimes increased the aggressions. Grimwood (1997) shows that the nuisance in homes causing unease among neighbors, comes from music, television, radio, conversation, walking, impact of windows, doors and cupboards and appliances such as washing machine, vacuum cleaner and telephone. In his work, Grimwood also shows that complaints are made by residents whose buildings are insulated with indices lower than recommended by specific legislation, as expected, or by residents whose buildings meet specific regulations, however, the causes of noise are not controlled by regulations, for example, impact doors, causing dissatisfaction with the building where they live. Also it shows that aggression may increase with the same intensity of the annoyance caused by noise.

In 1993, Mathys shows in his work that the building codes of Belgium, France, England, Germany and Holland have a partial view of the defining acoustic comfort in buildings, since it goes beyond the value of the insulation of walls or floors. The comfort depends also on the external noise and the reverberation time in indoor environments. However, the building codes neither consider these parameters, nor the noise from the kitchen and hydro sanitary systems. In a special way, Mathys draws attention to the nuisance caused by noise sources with predominance at low frequencies.

While users of residential buildings are looking for acoustic comfort, a subjective concept, the new standard provides a performance criteria (objective concept), among them, the acoustic one. The comfort depends on the performance of buildings and their acoustic characteristics.

In the study by Neto (2009) the concept of subjective acoustical comfort has been translated into objective concept through the Acoustic Comfort Level obtained from values of acoustic performance on the field and psychoacoustic parameters, such as speech intelligibility.

In this present work, only the concept of performance toward the new standard will be treated. And, specifically, the acoustical performance will be handled between independent housing units in vertical partitions on airborne sound and in horizontal partitions in relation to the impact noise by reason of the high rate of complaints from neighbors, including the increase in lawsuits

BRIEF HISTORY OF STANDARDS AND CRITERIA FOR ACOUSTIC PERFORMANCE

Indeed it is the importance of technical standards, since they are the basis for ensuring the quality of any product that is marketed. According to market needs standards our building codes need to be created or revised. Until 2008 the market for Brazilian civil construction was in need of a standard to indicate the minimum performance that buildings and building systems should provide, before being released to the market. Brazil is the last of other countries in Latin America with the publication of a performance standard. Chile was the first to publish a performance standard in 1961. Argentina issued its first standard in 1985 (Neto, 2009).

The preparation of documents, as standards, ordinances or regulations specific, dealing with issues concerning the sound insulation in buildings is compared with recent history of civil construction. In Brazil, for example, the concept of performance applied to the construction, as it is known today, began in the late 60s (Mitidieri Filho, 1998). Since then, it increased the number of vehicles on the roads, the number of noise sources and, as several residential buildings were built, it raised the concern with the acoustic comfort and it tends to increase even more.

Europe has high concern about the building performance and the standards used to help maintain appropriate conditions for the use and habitability of buildings. In the work of Goydke (1997) it has been presented the cooperation between the International Organization for Standardization (ISO) and European Committee for Standardization (CEN) in order to revise or update the standards that deal with acoustic performance of buildings.

The ISO (International Organization for Standardization) officially began its work in February 1947, aiming to unify industrial standards. The concern about noise in relation to comfort came with the creation of the first standards that dealt with comfort in the 60s and 70s. ISO R1996, which presents a table with the community reaction against the increasing noise, only appeared in 1971. A later version of 1971 replaced this table. The most current version of this standard, including ISO 1996-1 (2003), ISO 1996-2 (2007), is divided into two parts and does not present such a table, leaving the discretion of each community (Neto, 2009).

In the late 19th century, the regulamentations were specific for buildings to reduce fire risk and structural stability. In the early twentieth century engineers noticed that the low sound insulation of walls between housing units would start the conflicts between neighbors and the welfare of the residents of the residential buildings. The first regulations aiming to performance and acoustic comfort were often comparative and qualitative, for example, "sound insulation as good as a wall of bricks or other construction that arises from the same sound isolation." In 1960 ISO / R 140 provides procedures for measuring the acoustic performance, but only in 1968, it arises the first international standard dealing with the assessment of sound insulation of dwellings: ISO / R 717, based on research of Gösele and Fasold (Rasmussen and Rindel, 2005).

In Delft, Netherlands, it happened in the 50s, the first International Congress on Acoustics (1st International Congress on Acoustics, ICA). In it, there was a symposium with presentations on sound insulation made by Kosten, Cremer and Gösele. In the 60s, it comes the first version of the Dutch standard performance NEN 1070, which was similar to ISO R 140 (Gerretsen, 2003).

In 1972, it occurred in the State of Philadelphia, USA, the first symposium (Performance concept in building) on the concept of performance applied to the building (Mitidieri Filho, 1998).

In France, the history of regulations to limit noise levels in residential buildings is recent. The first deliberation on the acoustic insulation of housing buildings (Code of Construction and Housing) is dated of June 14, 1969, by decree applicable on January 1st 1970. The dwellings built between 1955 and 1969 were subject to an imprecise regulation that required manufacturers to a qualitative limitation for the acoustic isolation, defined only as "enough." The buildings that were built before 1955 were not subject to any regulatory standard about acoustic comfort. Nowadays, the new set of rules, more demanding than the previous one, and that follows the European normalization, was deliberate on June 30, 1999, applying from January 1st 2000. It sets the criteria presented in the NRA (Nouvelle Réglementation Acoustique des Batiments) (Meisser, 2005).

In Brazil, the initial assessment of the performance and acoustic performance of residential buildings was developed by the Institute for Technological Research, IPT, however, to ground habitations in the early 80s (Mitidieri Filho, 1998). The IPT Report No. 16.277, published in 1981, was one of the earliest documents drafted with this concern, not only dealing with acoustic comfort, but also other aspects of building, such as thermal comfort, fire safety etc. (IPT, 1981).

BRAZILIAN CRITERIA: STANDARDS AND LEGISLATION

The standards and legislations are the means used to establish criteria as stated for the community. About the performance of buildings, the NBR 15575 (2008) is the first Brazilian standard. Before that, however, other standards were used to define the comfort of users, and they are listed below.

ABNT NBR 10151 e ABNT NBR 10152

The Brazilian standard relevant to the assessment of environmental noise is to ABNT NBR 10151 (2000) - Acoustics - assessment of noise in populated areas, to ensure the comfort of the community - a procedure that provides for the measurement and assessment of levels of urban sounds, and define the values of "Level of Evaluation Criteria for outdoors" for different types of land use areas, at the Table.1. This standard establishes noise levels for specific areas of occupation. There is no mention, however, about the noise created inside the buildings in these areas.

Table 1. Level of Evaluation Criteria, NCA, for external environments from buildings dB(A)

Land use category	Day	Night
Rural and semi-rural areas, lifestyle blocks	40	35
Strictly residential urban areas, hospitals, schools	50	45
Mixed area, predominantly residential	55	50
Mixed area, with commercial or administrative roles	60	55
Mixed area, with recreational roles	65	55
Predominantly industrial area	70	60

Source: (ABNT NBR 10151, 2000)

As mentioned, this standard sets the limits for environmental noise. Is not used to evaluate the noise inside the buildings. For this situation there are ABNT NBR 10152 (1987) - Levels of noise for acoustic comfort, that sets the limits for cer-

tain background noise indoors in the building shown on Table.2. There is no mention about the acoustic performance of components and building systems.

Table 2. Level of Evaluation Criteria, NCA, for indoor environments dB(A)

Place – Residences	dB(A)	NC
Bedrooms	35-45	30-40
Living rooms	40-50	35-45

Source: (ABNT NBR 10152, 1987)

BRAZILIAN LAWS

The Conselho Nacional do Meio Ambiente (CONAMA) was established by Law nº 6.938 of August 31st, 1981 (BRAZIL, 1981) as the responsible for setting noise limits. The Resolution CONAMA by being a general rule, according to the Federal Constitution, must be obeyed by states and cities.

By CONAMA Resolution no. 001, March 8th, 1990 (BRAZIL, 1990a), it were established the environmental noise limits according to ABNT NBR 10151 (2000). The ABNT NBR 10152 (1987) is also mentioned in this resolution, but only at the condition that the limits are not exceeded in the cases of execution of works or building construction.

In São Paulo, the Article 2 of Act nº. 11.780 of May 30th, 1995 (São Paulo, 1995) stabilishes the obligations of the public hall and the owners or developers of buildings the control of noise pollution in São Paulo city.

Owners or developers of new buildings to be built in São Paulo city will adopt technical measures to protect users of these buildings against noise pollution in its own site. (Act nº. 11.780 *apud* Carneiro, 2004, p. 280).

This law even complements that in buildings for residential condominiums it shall be issued technical reports of local noise and, along with the project, preventive measures should be taken with constructive solutions to the noise levels of standard ABNT NBR 10152 (1987) are obeyed (Carneiro, 2004).

There are other federal, state and municipal ordinances that aim to contain the increase in noise environment. Mentioning also fot the city of Sao Paulo we have:

- Act (municipal) nº. 11.501, April 11st, 1994, which "provides for the control and supervision of activities that govern noise pollution" (*apud* Carneiro, 2004).

• Act (municipal) nº. 11.804, June 19th, 1995 which is even stricter than the CONAMA Resolution nº. 001, as it requires compliance with the limits of ABNT NBR 10 151 (2000) also applying in the construction industry (*apud* Carneiro, 2004).

• Decree (municipal) nº. 34.569, October 6th, 1994, which instituted the Urban Silence in São Paulo, known as PSIU (*apud* Carneiro, 2004).

And under Federal Law of Condominium:

• Act nº. 10.406, January 10th, 2002, where it is included in the part known as the Condominium Act. In Article 1336, Chapter VII, it is defined as joint owner's obligations regarding the use of their parts in building that "not to use in a manner to bother the peace, health and safety of the owners, or morality" (Brazil, 2002).

It appears, then, that there are laws that demonstrate concern for the environmental noise and comfort of users inside their buildings. The judiciary has used these and other tools to protect users from noise problems with the neighborhood.

ABNT NBR 15575 – Performance of buildings

The performance standard for residential buildings, from ABNT, approved in 2008, NBR 15575, is the first of its kind in Brazil. It is an important document that reflects the concern to improve the conditions of use and habitability of buildings, presenting acoustic performance criteria. Therefore, it is expected to be a new basis, clearer and more objective for the legal proceedings because, currently, in the case of inconvenience to residents by noise from the neighborhood, the ABNT NBR 10152 (1987), sound levels for acoustic comfort is one of the most important bases for the expert reports. However, according to Baring (2002), the ABNT NBR 10152 (1987) is improperly used, since the text is exiguous and elusive, making it easily disputed in legal proceedings.

The ABNT NBR 15575 (2008) (residential buildings of five floors up - performance) is divided into six parts: Part 1 refers to the general requirements; Part 2, requirements for structural systems; Part 3 requirements for internal floor systems; Part 4, requirements for internal and external wall systems; Part 5 requirements for roofing systems and, finally, Part 6, hydro sanitary systems. Although the new standard was made for buildings up to five floors, the first part of this standard shows a note located within the scope (section 1) which states that "The requirements and criteria established in this Standard can be applied to residential buildings or systems with more than five floors, except those that directly depend on the height of the building" (ABNT NBR 15575-1, 2008, p. 1). Therefore, the acoustic performance addressed in the standard could be extended to buildings over five floors.

The performance standard (ABNT NBR 15575, 2008) is important for both the consumer and the construction industry. The consumer will be confident that the product he is buying has the minimum quality specified in technical standards and by the Code of Consumer Protection (Brazil, 2002). The civil construction industry, that involves the engineers, building constructors and producers of specific materials to civil construction, will have a base to put in the market a product with the minimum quality requirements for habitability and use, obtained with respect to technical standards.

It is expected that this standard of performance, becoming now, a technical reference for designers, suppliers of materials for construction, builders and consumers, will reduce the rates of complaints from users as well as the legal processes that are subjected those who disrespect them.

The peaceful coexistence between neighbors necessarily depends on a good acoustic insulation providing the comfort and privacy. The level of acoustic insulation that meets the needs of users in relation to privacy will be studied in this work.

The background noise is an important item in determining the criteria, because, for the comfort, the homes located in areas with high levels of background noise need more insulation. The dwellings placed where there are low levels of background noise need a smaller acoustic. Regarding the intelligibility of speech, the opposite happens, i.e. if the environment is in a place with low background noise, a greater isolation is required. If background noise is low, any noise (or conversation) is easily perceived, and may cause discomfort, hence the need to increase the insulation. On the other hand, if the background noise presents high levels, the noise can only be

perceived to present higher levels of background noise. In this case, isolation may be less stringent than in the previous case. The Part 4 of the performance standard ABNT NBR 15575-4 (2008) mentions that the establishment of the performance level of the building must be compatible with the level of background noise of the site of the work.

The ABNT NBR 10152 (1987) sets the levels for background noise for comfort and suitable for every kind of environment. The criteria are required when noise levels, except the background noises are loud enough to interfere negatively in the activities involved in each environment. In homes, for example, activities carried out that require low noise levels are the rest of the dialogue (conversation), leisure (reading, watching TV), and radio. (Lalli, 1988).

According to Souza (1982), assessing the performance of the building, that is, their behavior in use, is based on requirements and criteria, and assessment methods that allow checking the attendance of the building and its parts, the conditions established. Mitidieri (1998, p.37) adds that "the requirements and performance criteria express, respectively, the quantitative and qualitative conditions to which the building must meet to satisfy the requirements of the user, when subjected to certain conditions of exposure."

Mitidieri (2002) states that there will always be minimum performance criteria to be met. Under these criteria, you can have housing quality or performance is not desirable.

The standard approved in 2008, ABNT NBR 15575 (residential buildings of five floors up - performance), however, active on May 2010, involves several requirements for a building that meets the requirements of users about housing and use.

The ISO 6241 (1984) was the basis for defining performance requirements, becoming a technical translation and objective for the needs of users. The performance standard includes the following requirements: structural performance, fire safety, safety in the use and operation, air tightness, thermal performance, acoustic performance, visual performance (natural and artificial lighting), durability and maintainability, comfort and tactile requirements, dynamic requirements and environmental suitability (Bennett, 2009).

The requirements of users, according to ABNT NBR 15575 (2008) and used as reference for establishing the requirements and criteria are safety, liveability and sustainability. The item **Security** refers to the structural safety, fire safety and security in the use and operation; the item **Habitability** refers to the tightness, thermal comfort, acoustic comfort, lighting comfort, health, hygiene and air quality, functionality and accessibility and comfort and tactile dynamic and the item **Sustainability** in the question refers to the durability, maintainability and environmental impact.

The ISO 6242-3 (Building construction - Expression of users' requirements. Part 3: Acoustical requirements), as amended in 1992, presents the factors with which they should be based on the criteria of noise (or discomfort), including: activities to be undertaken and which rely on acoustic comfort, such as sleeping, reading, studying, working in offices; percentage of people that must be met; duration which should be between a noise and another (to places where it there are intermittent sources of noise), level of background noise is acceptable.

The IPT Report nº. 16.277, published in 1981, probably one of the first to address the acoustic comfort in buildings in Brazil, already presented as a requirement that "the element common wall (...) is to provide sound insulation at or above the minimum value compatible with the needs of speech privacy between homes "(IPT, 1981, p.15).

This standard does not rule out ABNT NBR 10151 (2000) and ABNT NBR 10152 (1987), but the opposite, in item 2.2.1 of Part 1, states that "The building, subject to limits external sound stimulus specified in ABNT NBR 10151, must meet the limits specified by ABNT NBR 10152 in relation to noise levels in their indoor "(ABNT NBR 15575-1, 2008, p. 20).

Else most other similar international documents analyzed, providing a value for a single performance, this standard provides criteria for three levels of performance: M - for minimum level; I - for intermediate level and S - for superior level.

This standard presents the values for the minimum performance level in the body of the standard, which is what is required. Already the values for the performance of intermediate and superior levels have been moved to an informative annex, as the requirement of the criteria. According to ABNT, must meet the minimum performance. This means that a very high standard of building can be sold with a minimum performance criterion.

The item 12.2 of part 4 of this standard establishes requirements for Internal and external systems of wall and aims to "provide acoustic isolation between the external and internal as well as between different condominium units, and provide, in addition, sound insulation between branches of the same unit, while for the night rest, leisure and domestic intellectual work "(ABNT NBR 15575-4, 2008, p.24).

The Table 3 shows the levels of criteria for airborne sound insulation for field and laboratory measurements, to the vertical partitions between residential units. Just to facilitate visualization the values for the three levels of performance are presented in a single frame in the same presentation as is the annex of the standard.

Table 3. Weighted standardized level difference, $D_{nT,w}$, for field measurements and weighted sound reduction index, R_w, for laboratory measurements

Element	$D_{nT,w}$ (dB)	R_w (dB)	Performance Level
Freestanding wall between residential units (wall twinning)	40 a 44	45 a 49	M
	45 a 49	50 a 54	I
	≥ 50	≥ 55	S

Source: (ABNT NBR 15575-4, 2008)

In the part 3 of the standard of performance, item 12.2, the requirements for establishing systems of internal floors and aims to "ease the passage of sound resulting from impact noise (walking, falling objects and others) between housing units" (ABNT NBR 15575-3, 2008, p.12).

The Table 4 presents the criteria for impact noise levels for field measurements for the horizontal partitions between adjoining residential units and, again, to facilitate the distion, the values for the three levels of performance are presented in a single frame of the same how they are in the annex of the standard.

Table 4. Impact noise level criteria – weighted standardized impact sound pressure level, $L'_{nT,w}$.

Element	$L'_{nT,w}$ (dB)	Performance Level
Slab, or other element therefore, with or without the counter, without acoustic treatment	< 80	M
Slab, or other element therefore, with or without the counter, with acoustic treatment	55 a 65	I
	< 55	S

Source: (ABNT NBR 15575-3, 2008)

The Figures 3 and 4 provide a comparison between the Brazilian criteria of the new performance standard and the international criteria. In the item below shows the international criteria surveyed.

INTERNATIONAL CRITERIA

The countries with colder climates are somehow privileged over the issue of sound isolation. It happens because, due to low temperatures, the environments need good heat sealing, sound insulation, then, is privileged with this seal. Moreover, as winter is long and the nights are too long, the residents need and want their homes a higher sound insulation, since the background noise levels are also lower.

In countries with similar weather to Brazil, where the climate is conducive to the windows remain open, get a high value of acoustic insulation, may be a more difficult task.

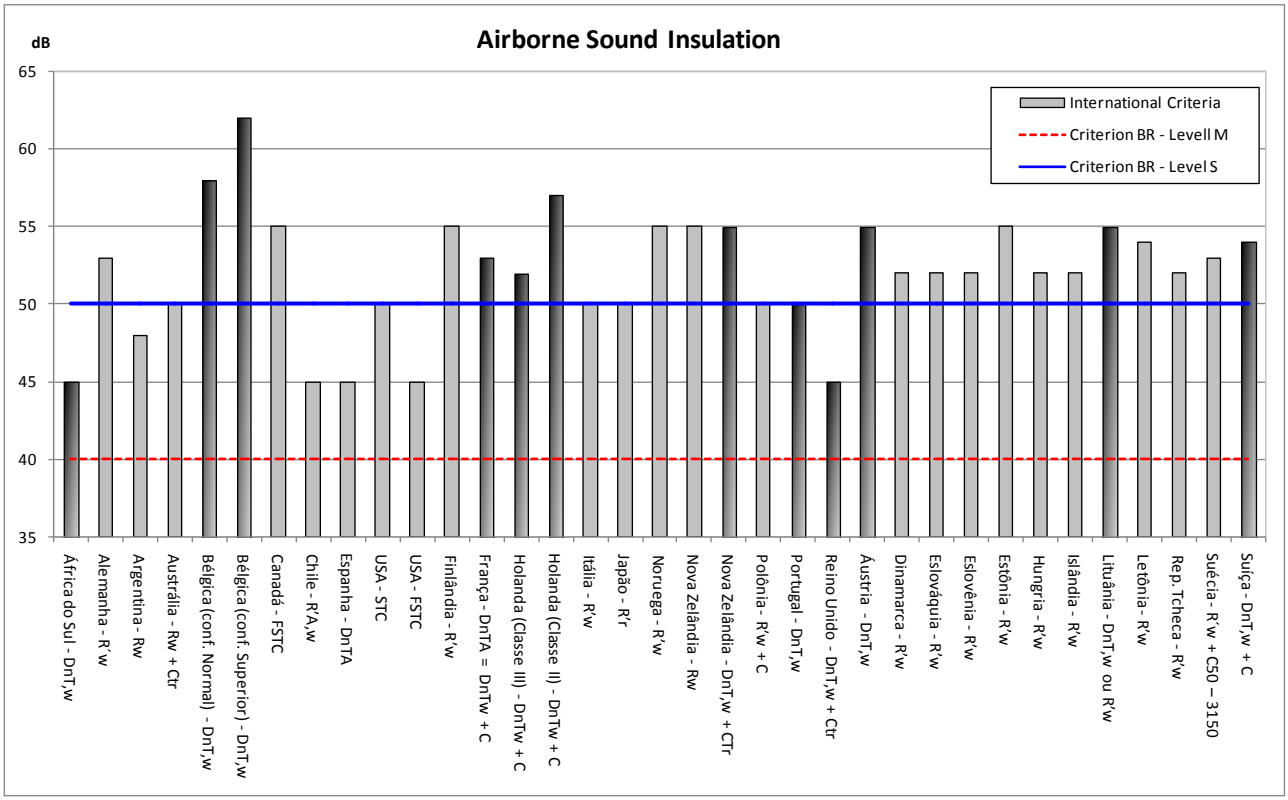
The Figure 3 shows the values of insulation from airborne noise in vertical partition between housing units required in international standards, besides the Brazilian criteria levels M, less demanding and S, more demanding. One should not make a direct comparison, quantitative, since there are several different acoustic parameters.

Thus, it can make a qualitative comparison between the criteria of various countries, shown in Figure 3. The bars in darker tone, are countries that use the same acoustic parameter than Brazil and it can be compared quantitatively. In Figure 3 the continuous line (blue) represents the criterion for the level of superior performance, S, and the dashed line (red) represents the criterion for minimum performance level, according to ABNT NBR 15575-4 (2008).

It is observed from Figure 3 that ten countries are using the same acoustic parameter than Brazil. Compared with the numerical values, the criterion of minimum performance level, M, Brazil is 5 dB below the minimum value found among these ten countries. The top level, S, of Brazil, is 5 dB above this minimum value found and is still down seven of these countries. In a qualitative comparison, the M level is also below 5 dB compared to other countries. However, as the parameters are different, this difference cannot be real.

South Africa, which uses the same acoustic parameter than Brazil has weather similar to the Brazilian climate and presents a criterion that corresponds to the intermediate level of standard from ABNT. Stands in the graph in Figure 3 how Belgium is strict with the criteria for isolating airborne noise.

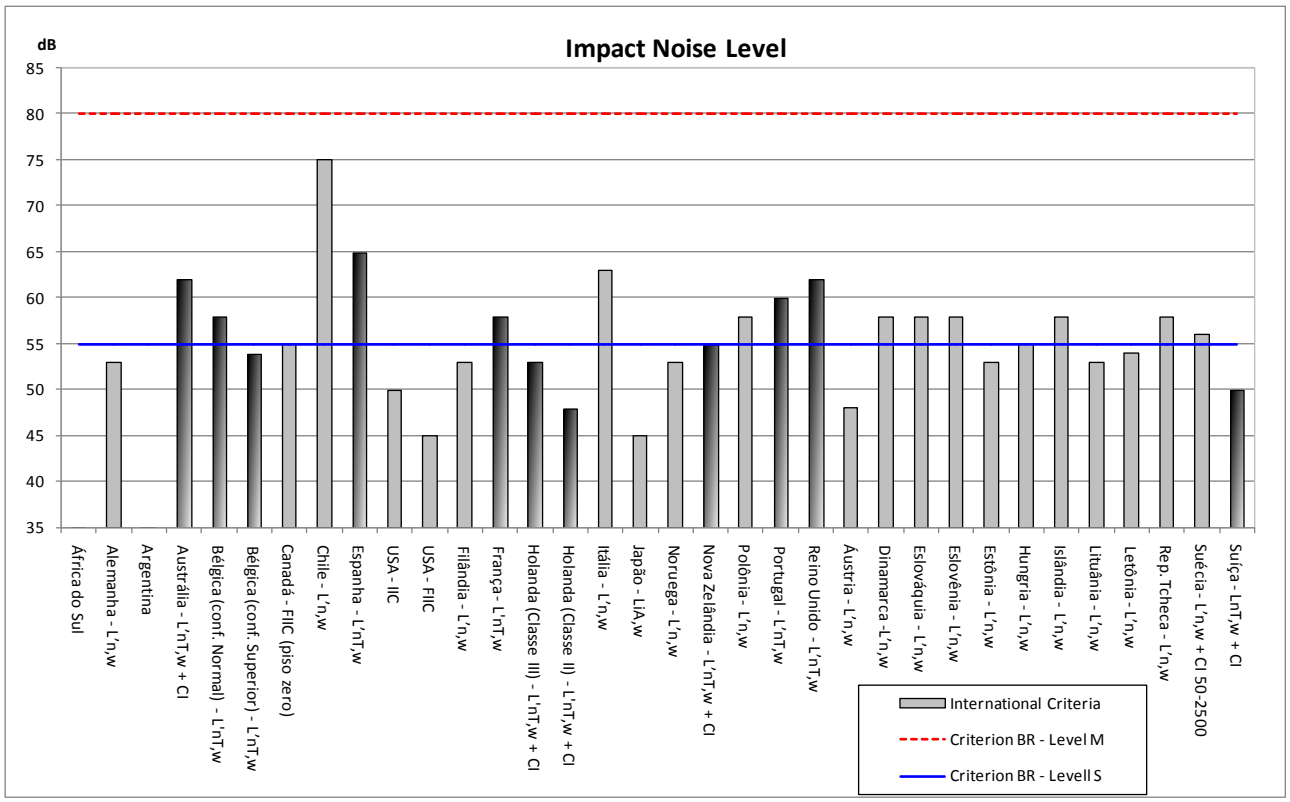
As mentioned, in the Figures 3 and 4, the bars in darker tone, are countries that use the same acoustic parameter that Brazil may be a quantitative comparison.



Source: (NETO, 2009)

Figure 3: International and Brazilian for airborne sound insulation for partition between residential units.

The Figure 4 shows the criteria to the impact level of the countries surveyed for qualitative comparison with the Brazilian criteria. It notes that the criterion of the minimum, M, which must be serviced according to ABNT NBR 15575-3 (2008), is above of those countries using the same acoustic parameter than Brazil, as other countries, using other acoustic parameters (compared to the absolute value). Again it is emphasized that the comparison with different parameters may not show the absolute difference real. There are also the countries Belgium, Netherlands, Switzerland and Norway have more stringent values than the Brazilian criteria. There were no criteria for impact noise floor of documents from South Africa and Argentina. Chile has relatively high value qualitative but not quantitative approaches, the minimum criterion of ABNT. Spain surprised with the highest criterion among the European countries studied.



Source: Autors´ archive.

Figure 4: International and Brazilian criteria for impact noise level between residential units.

The approval of the performance standard was an important step so that there is a better match acoustics of the buildings in order to present consistent acoustic performance with the expectation of consumers. Although the new standard is in force recently for the forthcoming review several issues that deserve careful attention, for example, the obligation of contractors to disclose the results of measurements and assessments of the performance of their buildings, including them in the descriptive memorial, al least as an appendix placed after the construction and measurement, as well as the level of performance as the results. Relate the level of performance with the standard of the work; thereby building a high standard must necessarily produce higher performance level. The inclusion of the simulation of acoustic performance by specific software is another suggestion for the first revision of the standard. That's because the builders want to know the performance level of their works, even on the project, to be able to make future improvements. It is a further suggestion to adjust the minimum performance criterion with other countries, since the value of the Brazilian standard is below the value of the criterion of countries like South Africa The addition of the adjustment coefficients of the spectrum, C and C_{tr} can scare the principle for making the most stringent criteria but enriches the form of expression, stating in more detail on performance against specific noises, for example, the low frequency.

CONCLUSIONS

The Brazilian criteria are very benevolent in construction when compared with international criteria. Brazil still has much to learn in terms of acoustic performance and comfort. The approval of the performance standard for buildings of five floors up was a victory but we can already give beginning to the thoughts order in the next revision of the standard. Until that time, manufacturers and construction companies will have had sufficient time to improve their products and provide buildings with better sound quality to its customers. Likewise, it should be placed more clearly in the body of the standard, the difference between the performance levels and standard of buildings. There is no sense building a high standard, with apartments in the house with values of 10^6 Reais, to be sold with minimum performance level like popular home! The standard also suffers not to insist on disclosure of the result of performance of a building in the documentation. You are entitled to know about the performance of the building that he is getting but not everyone knows that there is a standard that addresses this issue.

REFERENCES

1. ABNT NBR 10151: Acústica-Avaliação do ruído em área habitada, visando o conforto da comunidade. Procedimento. Rio de Janeiro. 2000.

2. ABNT NBR 10152: *Níveis de ruído para conforto acústico*. Rio de Janeiro. 1987.
3. ABNT NBR15575-1: Edificios habitacionais de até cinco pavimentos-desempenho. Parte 1: Requisitos gerais. Rio de Janeiro. 2008.
4. ABNT NBR15575-3: Edificios habitacionais de até cinco pavimentos-desempenho. Parte 3: Requisitos para os sistemas de pisos internos. Rio de Janeiro. 2008.
5. ABNT NBR15575-4: Edificios habitacionais de até cinco pavimentos-desempenho. Parte 4: Sistemas de vedações verticais internas e externas. Rio de Janeiro. 2008.
6. Austrália. New South Wales (NSW). Department of Environment and Conservation Dealing with neighborhood noise. 2ed. Australia. 2006.
7. B. Rasmussen, J. H. Rindel "Concepts for evaluation of sound insulation of dwellings - from chaos to consensus?" Proceedings… Forum Acusticum 2005. Budapest. 2005.
8. Brasil. Act nº 6.938 de 31/08/1981.
9. Brasil. Act nº 10.406 de 10/01/2002.
10. Brasil. Resolução CONAMA nº 001 de 08/03/1990.
11. C.A.M. Borges. "O que são as normas de desempenho e como entrarão em vigor?" Lecture in Sinduscon-RJ. <www.sinduscon-rio.com.br/doc/normas.ppt>. 2009.
12. M. Meisser. Réglementation acoustique des bâtiments. *Technique de l'ingénierie*, revue on line, code C 3 365, France, 2005.
13. C. Grimwood "Complaints about Poor Sound Insulation between Dwellings in England and Wales" *Appl Acoust*, 52, n. 3/4, p. 211-223. 1997.
14. C. V. Mitidieri Filho "Avaliação técnica de novos produtos para construção de habitações". Interview 2002.
15. C. V. Mitidieri Filho *Avaliação de desempenho de componentes e elementos construtivos inovadores destinados a habitações: proposições específicas à avaliação do desempenho estrutural*. Thesis. University of São Paulo. 256 f. 1998.
16. D. A. Laird e K. Coye "Psychological measurements of annoyance as related to pitch and loudness". *J. Acoust. Soc. Am*, p. 158-163. 1929.
17. E. Gerretsen "Prediction of sound insulation in buildings: a tool to improve the acoustic quality". In: DAGA 2003, at Institut für Technische Akustik der RWTH. Proceedings… Aachen, Germany. 2003.
18. Ed. Abril, *Veja São Paulo*, nº 2060, de 14/05/2008.
19. Ed. Abril, *Veja São Paulo*, nº 2162, de 28/04/2010.
20. F. P. Lalli "Critérios de ruído" in *Tecnologia de Edificações*. São Paulo: PINI/ IPT, p. 453-456. 1988.
21. H. Goydke "New International Standards for Building and Room Acoustics" *Appl Acoust*, 52, n. 3/4, p. 185-196, (1997).
22. IPT - Instituto de Pesquisas Tecnológicas. Report nº 16.277 – *Formulação de critérios para avaliação de desempenho de habitações. São Paulo*. 1981.
23. ISO 1996-1: Acoustics - Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures. Geneve. 2003.
24. ISO 1996-2: Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels Geneve. 2007.
25. ISO 6241: Performance standards in building - Principles for their preparation and factors to be considered. 1984
26. ISO 6242-3: Building construction - expressions for users' requirements - Part 3: Acoustical requirements. Genève. 1992.
27. ISO R 1996: Acoustics - Assessment of noise with respect to community response, Geneva, 1971.
28. J. G. A. Baring "Ruído Interno e Externo em Edificações: análise crítica da normalização brasileira" *In:* Encontro da Sociedade Brasileira de Acústica, XX., 2002, Rio de Janeiro – RJ. Anais... Rio de Janeiro: SOBRAC/INMETRO, 2002.
29. J. Mathys "Low-frequency noise and acoustical standards". *Appl Acoust*. 40, n. 3, p.185-199 (1993).
30. M. F. F. Neto *Nível de conforto acústico: uma proposta para edifícios residenciais*. Thesis. School of Civil Engineering and Architecture - State University of Campinas. 257f. 2009.
31. P. J. Barry "Desempenho acústico em edifícios habitacionais. Habitação: Desempenho e inovação tecnológica". Seminar in Instituto de Pesquisas Tecnológicas do Estado de São Paulo, IPT. São Paulo, 26-27 de outubro. 2005. pg 76-83.
32. R. Souza "A avaliação de desempenho aplicada a novos componentes e sistemas construtivos para habitações". *In*: V SIMPATCON - Simpósio de Aplicação da Tecnologia do Concreto. Anais... Campinas, 1982.
33. São Paulo (City) Decree nº 34.569 de 06/10/1994.
34. São Paulo (City) Act n.º 11.780 de 30/05/1995.
35. São Paulo (City) Act nº. 11.501 de 11/04/1994.
36. São Paulo (City) Act nº. 11.804 de 19/06/1995.
37. W. A. M. Carneiro. *Perturbações sonoras nas edificações urbanas*. 3ed. São Paulo: Editora Revista dos Tribunais, 2004. 332 p.
38. W. A. Utley, I. B. Buller "A study of complaints about noise from domestic premises". *J. Sound and Vib*., 127, n. 2, p. 319-330 (1988).