euronoise 2021
25th to 27th of October
Madeira, Portugal - online

Comparison of standard EN 12354 versions 2000 and 2017 applied to simulations of acoustic performance in buildings

Bárbara Fengler[1], Raquel Rossatto Rocha[1], José Carlos Giner[1]

[1]Giner
barbara@giner.com.br, raquel@giner.com.br, jcginer@giner.com.br

Abstract

In 2017 the standard EN 12354: 2000, which describes the calculation methods to estimate the acoustic performance of buildings based on the acoustic performance of the elements, was revised. Since then, the standard has also been considered an international standard: EN ISO 12354: 2017. The most notorious change is the separation between Type A and Type B materials. These materials are classified according to the secondary sound transmission characteristics of the elements, this changes the norm result in the differentiation of considerations and calculation methods throughout the text and parts of the standard. Considering this and the other modifications, this article aims to compare the results of acoustic performance of buildings obtained through the two versions of the standard: EN 12354: 2000 and EN ISO 12354: 2017. For this, the application of the calculation procedures of both versions of the standard 12354 was carried out using the commercial software SONarchitect ISO version 3. The compared parameters are those described by the Brazilian standard ABNT NBR 15575: 2013 for vertical external element (facade) and internal (partitions) and air and impact noise for floor systems. The simulations were carried out with three models of the same building, with differences on the construction elements: only Type A materials, only Type B materials and both materials. The simulated results show that the biggest differences between the two versions of the standard happen when the elements of the model are Type A and B. Also, the biggest variation in the result in each of the compositions is for air noise of floor systems between ambient environments with different volumes. The results of the simulation of the real model are compared with the measurement and the results show that the simulation with the ISO 12354: 2017 have more accurate values.

Keywords: simulation, performance, measurement.

1 Introduction

Technical standard NBR 15575 - Residential Buildings – Performance [1] was approved in Brazil in 2013, and it is divided into six parts. This performance standard [1] establishes acoustic requirements for airborne noise which must be met by existing vertical sealing elements (both external and internal). Floor systems, on the other hand, must comply with airborne and impact noise criteria. All these requirements are filed under categories to meet the minimum (M), intermediate (I) and superior (S) performance levels, seeing that meeting at least the minimum performance level is mandatory.

For most agents within the production chain, the NBR 15575 standard [1] generates a "good competition" environment, since it encourages the investments spent in improvements and development, technology and sustainability. On the other hand, Corbioli [2] points out to an estimated increase in production costs from

3% to 7%, depending on the performance goals to be met: minimum, intermediate or superior levels. According to a study by SINAENCO [3], especially the increase in costs and the need for stricter controls could force some kind of “natural selection” among market competitors.
In this sense, there’s a need for savings on the part of construction companies. To that end, carrying out computer simulations of the performance marks attained over several disciplines constitutes good practice in trying to avoid future problems, complaints and expenses unforeseen to the budget. The search for and utilization of acoustic performance simulations for residential buildings has been increasing steadily and is deemed a fundamental tool for developing new projects in the field of construction in Brazil.
Nonetheless, computer simulations, and acoustic performance among them, are somewhat simplified and assume ideal conditions. It is known, however, that there might exist uncertainties associated with work execution. It is inevitable and natural that there will be divergences between simulated and measured values in the field after execution, though such difference is expected to be minimal. It becomes yet necessary to stress that the methodologies used for these performance simulations must undergo constant development to obtain increasingly accurate results. As an example, it is worth mentioning the revision of the ISO 12354 standards in its parts 1 to 3 [4-6], which present the calculation methodology for determining the acoustic performance of various systems.
Parts 1 to 3 from EN 12354 [7-9] have undergone revision, having turned into ISO standards [4-6] in 2017. Rosão and Silva [10] point out that among the changes in this standard’s new version there stands out the division of element types between Type A and Type B materials, such separation taking place according to these elements’ structural reverberation times. Besides other revisions regarding the definitions and calculation procedures presented, such division in element categories have caused revisions throughout all of the sections of this standard, since calculation methodologies have undergone differentiation depending on the types of elements under consideration. Therefore, the fact of taking into consideration the acoustic transmission through fringes has also been subject to major changes, seeing that distinct factors are employed depending on the type of elements being connected.
In such a sense, it is natural that there exist divergences in results depending on which calculation methodology is employed. The goal of this study is to compare the results obtained through computer simulations by using each of this standard’s versions. The same model is employed for simulations considering exclusively Type A materials and exclusively Type B materials, as well as considering the real construction model in which both Type A and Type B elements are employed. By making use of the real model, simulation results are compared to results from both calculation methodologies, EN 12354:2000 [7-9] and ISO 12354:2017 [4-6], and the results obtained from field measurements. All simulations have been performed using the SONarchitect ISO acoustic performance simulation software version 3.0.12, in which it becomes possible to choose the version of the standard to be used for calculation methodology.

2 Method

The same residential building was employed as a case study for all of the steps of the analysis carried out in this study. The design of the building under consideration can be seen in Figure 1. In the following sections, the methodologies used for the simulation and field measurement steps shall be respectively presented. The acoustic performance descriptors evaluated, both for the simulations and tests, are those recommended by the Brazilian ABNT NBR 15575 standard [1]: evaluation of the DnT,w value for airborne noise between environments; D2m,nT,w for checking performance upon dorm façades; and L’nT,w for analyzing the acoustic performance regarding impact noise between environments located in distinct floors.

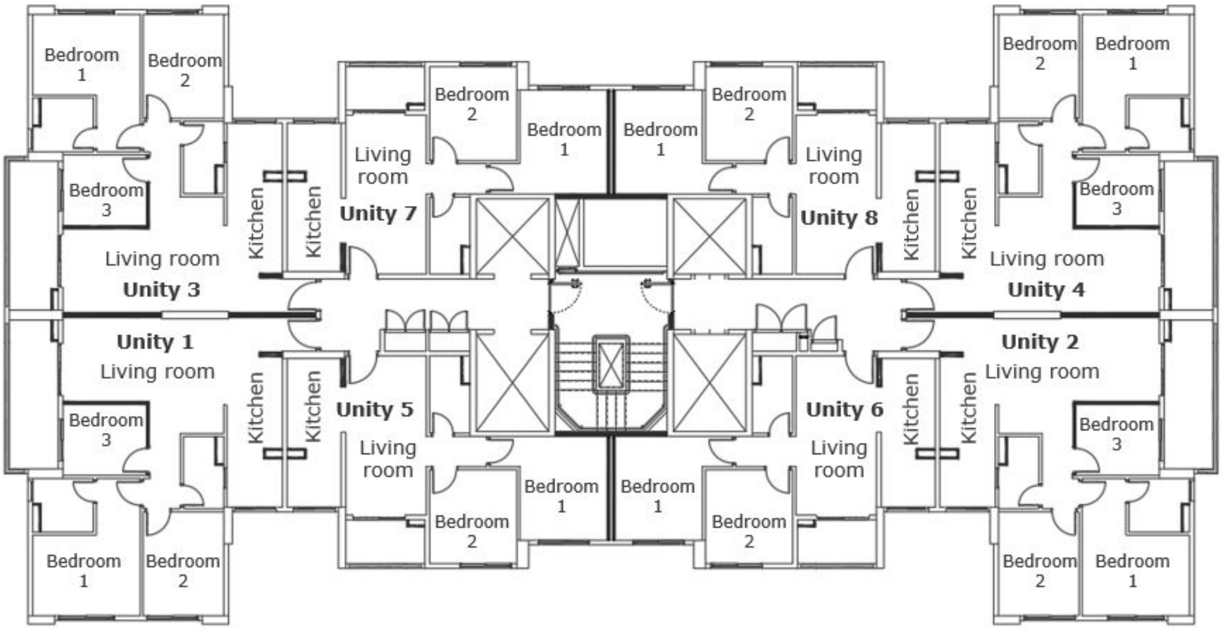

Figure 1 – The project employed in this case study.

2.1 Acoustic performance field measurements

The field measurements for confirming the compliance to the acoustic performance requirements established by the ABNT NBR 15575 standard [1], regarding the airborne noise between different units, were carried out according to the procedure described in ISO 16283-1 [11], by obtaining the values for DnT,w in distinct environments. Impact noise measurements are technically regulated by ISO 16283-2 [12]. Airborne and impact noise measurements are performed over third-octave frequency bands. By means of the processing described in the ISO 717-1 [13] and ISO 717-2 [14] standards, global values can be determined. Both sections of the standard technically specify all the requirements which must be met for the technical measurement procedure, from sound source parameter specifications, sound pressure level meters and microphones and their calibration, to the guidelines regarding the quantity and location of source and measurement spots. All specifications have been duly met in this study.

In general, the acoustic performance measurements for substantiating compliance with the requirements from the NBR 15575 standard [1] are carried out on a sample basis, and these are defined by the person in charge of the work aided by an acoustic specialist to check the most critical situations, and working from the compliance to a worst-case scenario, guarantee that the requirements for other situations are met as well. Yet, measurements are usually carried out for buildings possessing typical floorplan typologies, along one floor only, results being extrapolated to other floors, except in the cases where there are differences in constructive elements among floors. For the projects under scrutiny in this study, acoustic performance tests were carried out on a sample basis: the requirements arising out of relevant partitions in representative units were checked according to availability and work completion by the work team, and floor system measurements were carried out considering the most critical cases and checked by means of computational simulations. Figure 2 shows the markings regarding the partitions and floor system situations which have been tested.

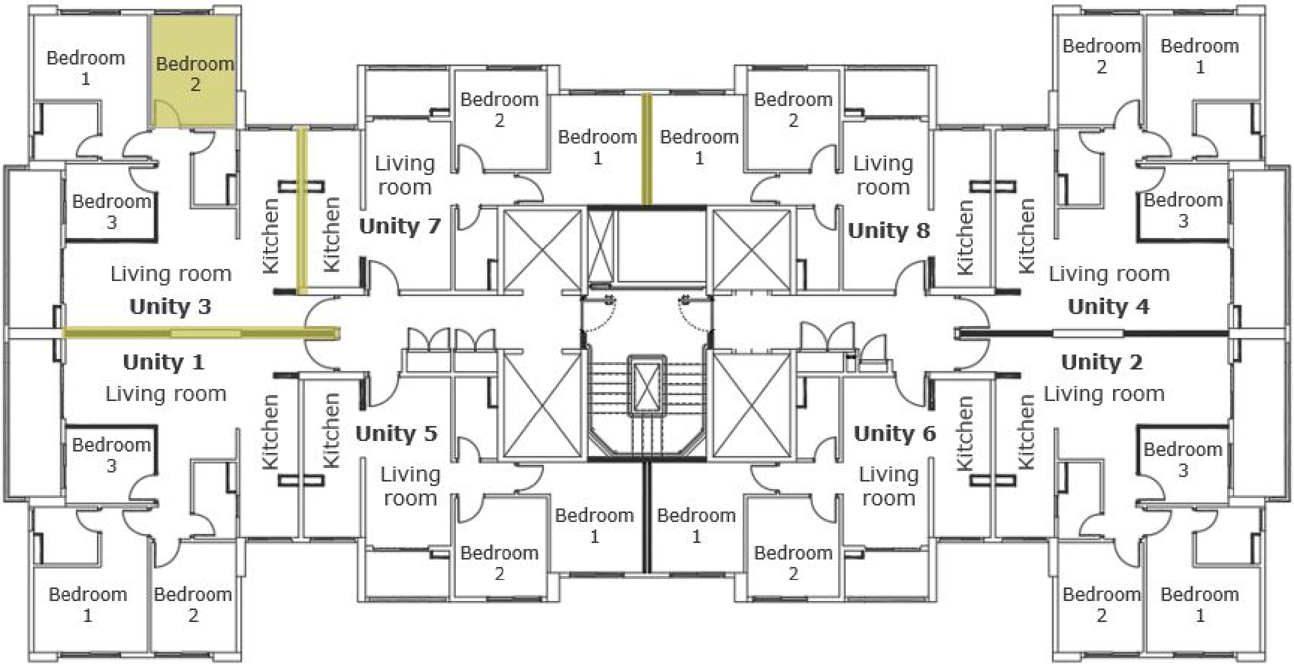

Figure 2 – Designation of the partitions and floor systems used for field measurements.

2.2 Acoustic performance simulations

A residential building model was employed in order to simulate the real model (as built), seeing that one model made use of Type A materials only and another model employed Type B materials only. All situations were simulated by using both calculation methodologies, according to the methodology from the EN 12354 standard: 2000 [7-9] and ISO 12354:2017 [4-6], making use of the SONarchitect ISO software. The simulation model devised was based on architectural and structural projects. Once the 3D model was finished, rooms' frames were inserted and other interferences existing between rooms were referred to. In order for the simulation to be carried out, a configuration of the parameters and requirements to be calculated must take place, as well as other operational software characteristics, and the acoustic performance requirements have been simulated according to Brazilian standard ABNT NBR 15575:2013 [1] for façades, internal partitions and floor systems, for the purposes of this study.

For the purposes of this study, simulation results regarding the same interferences as those measured in the field are presented in Section 2.1. In addition to these situations, façade performance values for Bedroom 2 in unit 3 were also checked in order to evaluate at least one case involving façade performance, and also the floor system from Bedroom 3 in the same unit, since this bedroom originally had all of its perimeter built in drywall except for the façade, while the other bedroom whose floor system was evaluated had its entire perimeter built from masonry. Furthermore, Bedroom 3's drywall construction allowed an option for its room to be expanded by opening up Bedroom 3's original area. Thus, the acoustic performance for the floor system in the expanded room in Bedroom 3 is presented in this study as well. Table 1 presents a summary of these composite spaces, both tested in the field and simulated, carrying the respective identifications used.

Constructive elements, in its turn, were modeled on Insul software and imported into SONarchitect ISO. Insul is a commercial software containing a materials database with their respective acoustic parameters. Besides having its own library, Insul allows the creation and analysis of new compositions, requiring information on a given material's characteristics such as thickness, density, modulus of elasticity and Poisson ratio. It is still possible to consider materials from suppliers who have carried out tests for their materials in the lab, by entering the data obtained through lab measurements in the software. For each simulation model, specific building element types were used as shown below.

Table 1 – Identification of the situations evaluated in the field, with further simulation.

Ident.	System	Field	Sim.
1.A	Floor system between Dorms 3 (un. 3) – airborne noise		X
1.I	Floor system between Dorms 3 (un. 3) – impact noise		X
2.A	Floor system between Dorms 2 (un. 3) – airborne noise	X	X
2.I	Floor system between Dorms 2 (un. 3) – impact noise	X	X
2.F	Dorm Façade 2 (un. 3)		X
3.A	Floor system for extended Room over Dorm 3 (un. 3) – airborne noise		X
3.I	Floor system for extended Room over Dorm 3 (un. 3) – impact noise		X
4.D	Partition between Kitchens units 3 & 7 – airborne noise	X	X
5.D	Partition between Rooms units 3 & 1 – airborne noise	X	X
6.D	Partition between Dorms 1 units 7 & 8 – airborne noise	X	X

2.2.1 Real simulation model

The real model is the simulation considering the construction elements according to the building's execution and construction. The building's structure is built in concrete, with pillars and solid concrete slabs according to the traditional construction methods employed in Brazil. External gaskets and the partitions between different units are made up of ceramic block masonry, with plaster coating for the dry areas and mortar with ceramic coating for the wet areas.
On the partitions between bedrooms from different units, to cater to the minimum necessary acoustic performance criteria, it became necessary to employ, on each side of the ceramic-block wall, a wall lining made up of drywalls. To reduce total composition thickness, 3.54-inch blocks were used. Therefore, the final composition of the partitions between bedrooms was made up of 3.54-inch ceramic block masonry with wall linings on each side, made up of 1.9-inch guiding rails and frames whose ends are finished by two 0.5inch plasterboards, not filled with mineral wool. Some internal unit partitions are made up of ceramic block masonry, while others are drywalls.
Regarding the composition of partitions between units, except in the case between bedrooms in distinct units, the Sound Reduction Index, Rw, was considered, obtained from laboratory tests carried out by the ceramic block supplier. The other compositions were modeled on the Insul software, according to the characteristics informed by the construction company. The building's simulation model in SONarchitect ISO is shown in Figure 3.

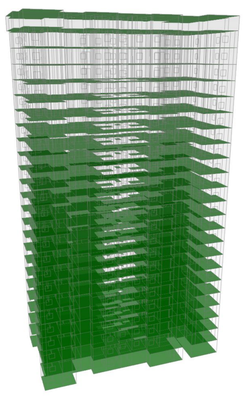

Figure 3 – Simulation model from SONarchitect ISO software.

2.2.2 Simulation model with Type A elements only

For this model, the real model was used as base and its internal drywall partitions were replaced by masonry ones, an element considered to belong to the Type A category. The other compositions have been kept, as well as the configurations and simulation requirements.
For such model's simulations, the goal was just to establish a comparison between the results obtained from each one of the calculation methodologies, seeing that any comparisons with the results obtained from field tests were not considered to be valid.

2.2.3 Simulation model with Type B elements only

Likewise, for the simulation model employing only Type B elements, the real model was also used as basis, while maintaining simulation configurations and requirements. For such a case, all Type A elements existing in the simulation were replaced by Type B elements, except for slabs and columns. All external gaskets were replaced by steel frame compositions, while internal partitions were replaced for drywall compositions only.
For the results obtained through such model's simulations, any comparisons with the results obtained from tests are not valid as well, since the model does not represent the building's execution situation. For this reason, and considering this model, only the comparisons between simulation results and the methodology from the EN 12354:2000 [7-9] and ISO 12354:2017 standards [4-6] are deemed valid.

3 Results

Table 2 presents the results obtained through the field measurements performed and results from the simulations subject to the same interferences, considering the real model. Simulated values are presented using the methodologies from standards EN 12354:2000 [7-9] and ISO 12354:2017 [4-6].

Table 2 – Comparison between measured and simulated results.

System	Quantity	Field result	Simulation according to the EN 12354:2000 standard [7-9]	Simulation according to the ISO 12354:2017 standard [4-6]
2.A	DnTw	49 dB	51 dB	49 dB
2.I	L'nTw	79 dB	80 dB	80 dB
4.D	DnTw	44 dB	45 dB	44 dB
5.D	DnTw	44 dB	44 dB	43 dB
6.D	DnTw	46 dB	47 dB	45 dB

From the results presented, it can be checked that the simulations according to the methodology from the ISO 12354:2017 [4-6] standard present greater accuracy with respect to the results obtained through field testing, exception made in case of the 5.D system. The results obtained through simulation by using the calculation methodology from the EN 12354:2000 standard [7-9] showed a deviation of up to 2 dB; however, when making use of the most recent methodology, the differences between measured and simulated results did not exceed 1 dB.
Table 3 presents the results obtained through the simulations for the three models in this study: the real model, the second model using only Type A materials, and the third model using only Type B materials. For each of the methodologies, the greatest divergences in results were found in the real model, which presented both element types. The smallest variations between the results simulated with the two methodologies were obtained in the model making use of Type B materials only. An important point to be mentioned is that considering the impact noise performance simulations, and for the case study evaluated, smaller variations

were identified in the values obtained between distinct versions of the standard within the same model than for airborne noise acoustic performance results.

Table 3 – Comparison between simulated results from distinct models.

		Real model		Type A		Type B	
System	Quantity	EN 12354: 2000 [7-9]	ISO 12354: 2017 [4-6]	EN 12354: 2000 [7-9]	ISO 12354: 2017 [4-6]	EN 12354: 2000 [7-9]	ISO 12354: 2017 [4-6]
1.A	DnTw	52 dB	50 dB	52 dB	50 dB	54 dB	54 dB
1.I	L'nTw	80 dB	80 dB	81 dB	81 dB	79 dB	79 dB
2.A	DnTw	51 dB	49 dB	51 dB	49 dB	53 dB	55 dB
2.I	L'nTw	80 dB	80 dB	80 dB	80 dB	78 dB	77 dB
2.F	D2m,nT,w	23 dB	22 dB	23 dB	22 dB	23 dB	22 dB
3.A	DnTw	50 dB	47 dB	49 dB	47 dB	55 dB	55 dB
3.I	L'nTw	81 dB	81 dB	82 dB	82 dB	79 dB	79 dB
4.D	DnTw	45 dB	44 dB	45 dB	44 dB	46 dB	45 dB
5.D	DnTw	44 dB	43 dB	44 dB	43 dB	45 dB	45 dB
6.D	DnTw	47 dB	45 dB	47 dB	45 dB	50 dB	51 dB

Although the construction system and slab characteristics have not changed between models, distinct acoustic performance values were obtained for floor systems, both for airborne and impact noise. Such differences between values highlight considering secondary transmissions, as well as the importance of correctly considering all of the model's constructive elements, even when considering that these systems are not under direct analysis.

When analyzing the simulation results for system 1.A, it can be checked that in the simulations for the three models and employing the calculation methodology from the EN 12354:2000 [7-9] standard, there is a 2 dB difference between the values obtained for each model, something which makes sense, considering that distinct construction elements have been used.

Nonetheless, considering the same system and the same changes of material for each model, a 4 dB divergence between the values obtained from the simulations according to the ISO 12354:2017 [4-6] standard was identified. This situation could also be observed for the values obtained from the 6.D system simulations, at even greater divergences between values. These situations may happen precisely due to the different considerations for sidewise transmissions between the standards under consideration, as well as the calculation methodology from the 12354:2017 standard [4-6], which takes these secondary transmissions more into account.

Last, it can be noticed that the greatest differences between the values obtained from each of the models and between the two versions of the standard take place in system 3.A, airborne noise from floor systems between the expanded room over Bedroom 3. In this case, the differences between the volumes for the emission and reception environments become considerable, seeing that the secondary transmissions become therefore even more relevant in order to attain the intended acoustic performance from the system.

4 Conclusions

By comparing the results obtained from the real model with the values obtained through field acoustic performance tests, it can be concluded that the simulations made in accordance with the calculation methodology from the 12354:2017 standard [4-6] are more accurate than the simulations carried out according to the EN 12354:2000 standard [7-9], something that is expected in fact from the revision of standards. In this sense, it is important to evaluate the use of simulations with the EN 12354:2000 standard [7-9], since it presents less accurate results, though ones close to the values measured as well.

The results obtained from the different simulation models show the importance of correctly considering the choice of sealing materials for the units' internal partitions. Although these systems are not directly evaluated to comply with the Brazilian ABNT NBR 15575 standard [1], the correct assessment of these elements is extremely important in order to ensure the accuracy of simulated results, since these elements are taken into account regarding sidewise transmissions.
Another important topic which was checked out in this study is the greater weight arising from these secondary transmissions in the simulations carried out by using the methodology from the 12354:2017 standard [4-6].

Acknowledgements

The authors wish to thank the Giner company for the availability of the software needed in order to carry out this study, as well as the construction company which allowed the use and publication of data from their projects, as well as their acoustic performance test results carried out in the field.

References

[1] Associação brasileira de normas técnica NBR 15575: Edificações habitacionais – desempenho, Rio de Janeiro, 2013.

[2] CORBIOLI, N. A norma está pegando: Visando um produto imobiliário de melhor qualidade, construtoras estão descobrindo os caminhos para superar dúvidas e dificuldades para o atendimento da NBR 15.575:2013, a primeira norma a estabelecer parâmetros mínimos de desempenho e durabilidade para edificações habitacionais do país. RevistaTéchne, Vol 235, 2016, 10-13.

[3] SINAENCO, Os impactos da Norma de Desempenho no Setor da Arquitetura e Engenharia Consultiva, 2020. https://sinaenco.com.br/wp-content/uploads/2016/08/OsIimpactosdaNormadeDesempenho.pdf.

[4] ISO 12354-1: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 1: Airborne sound insulation between rooms, 2017.

[5] ISO 12354-1: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 2: Impact sound insulation between rooms, 2017.

[6] ISO 12354-3: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 3: Airborne sound insulation against outdoor sound, 2017.

[7] EN 12354-1: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 1: Airborne sound insulation between rooms, 2000.

[8] EN 12354-1: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 2: Impact sound insulation between rooms, 2000.

[9] EN 12354-3: Building acoustics, Estimation of acoustic performance of buildings from the performance of elements, Part 3: Airborne sound insulation against outdoor sound, 2000.

[10] Rosão, V; Silva, J. Comparison of EN 12354-1 to -4 of 2000 with EN 12354-1 to -4 of 2017, Euronoise, Crete, 2018.

[11] ISO 16283-1: Acoustics — Field measurement of sound insulation in buildings and of building elements, Part 1: Airborne sound insulation, 2014.

[12] ISO 16283-2: Acoustics — Field measurement of sound insulation in buildings and of building elements, Part 2: Impact sound insulation, 2020.

[13] ISO 717-1: Acoustics — Rating of sound insulation in buildings and of building elements, Part 1: Airborne sound insulation, 2020.

[14] ISO 717-2: Acoustics — Rating of sound insulation in buildings and of building elements, Part 2: Impact sound insulation, 2020.