



VERIFICATION OF CONFORMANCE WITH SPANISH REGULATIONS – ACOUSTIC SAMPLING

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ABSTRACT*

In Spain, Basic document DB HR Protection against noise, establishes acoustic requirements in buildings. Acoustic testing is not mandatory at the national level, but several autonomous communities and local governments require testing the sound insulation of walls, floors and facades, as well as the sound pressure levels of building services to obtain the first occupation license, issued by authorities after the building completion.

The regulations regarding acoustic testing types and required sampling have been analyzed for three autonomous communities and three main cities.

The objective of this paper is to compile and analyze the regional decrees in Spain which require mandatory acoustic testing before the occupancy of the building, in a specific way, information on test sampling and other procedures will be shown.

Keywords: *Acoustic regulations - Verification of conformance – Pre- occupancy acoustic testing – Sampling.*

1. INTRODUCTION

Achieving an adequate acoustic quality indoors is essential for the comfort and well-being of occupants in dwellings. Good layout, a good selection of separating walls, floors and façade elements, proper detailing of junctions and a careful workmanship will prevent flanking transmission and lead to good sound insulation in buildings.

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Same principles apply for the noise control of building services: good planning, sizing, correct selection of acoustical materials and vibration isolators, together with site inspections, will limit the noise transmitted from service and equipment to the occupied spaces.

Acoustical advice is necessary during all the phases of the construction of a building: from the preliminary design stage to the construction. Pre-occupancy acoustic testing plays an essential role in ensuring the acoustic quality of a building. Some of the benefits of performing a sample of pre-occupancy acoustic measurements are the following:

- verification of compliance with building regulations;
- early detection of defects during construction, which will allow time for corrective action to be taken before the building is occupied;
- reduced risk of complaints;
- improved marketability of the building.

As opposed to single family houses, multifamily buildings have separating walls and floors, common areas, plant rooms, collective equipment, etc. which may cause annoyance to occupants due to noise and vibration. In Spain, 66.90 % of the dwellings, approximately 12.58M, are multifamily dwellings[1], which means most of the population lives in flats or apartments, where acoustics is key to ensure comfort, privacy and health.

Basic document DB HR Protection against noise[2], establishes acoustic requirements in buildings in Spain, but pre-occupancy acoustic testing is not mandatory at the national level, since the powers of building control are devolved to autonomous communities. That is the reason why several autonomous communities and local governments require testing the sound insulation before the completion of buildings. This paper compiles and analyses the regional decrees in Spain which require mandatory

acoustic testing, and it also compares the acoustic sampling plan of the acoustic classification scheme in Spain[3]. This paper also aims at potential learning from the experience of other countries.

2. ACOUSTIC REQUIREMENTS IN SPAIN

Tables 1 and 2 synthesize Spanish acoustic requirements in new build dwellings. Requirements for service and equipment noise are contained in RD 1367/2007[4]. Detailed information regarding the application of requirements is available in [2] and [4].

Table 1. Requirements for sound insulation for protected spaces, such as living rooms and bedrooms in new build dwellings in Spain.

Sound insulation	Type of spaces	Requirement
Airborne	Between protected spaces and other spaces outside the living unit ⁽³⁾	$D_{nT,A} \geq 50 \text{ dB}^{(1)}$
	Between protected spaces and noisy areas, such as equipment rooms or activity rooms	$D_{nT,A} \geq 55 \text{ dB}^{(1)}$
Impact	Between protected spaces and other spaces outside the living unit ⁽³⁾	$L'_{nT,w} \leq 65 \text{ dB}$
	Between protected spaces and noisy areas, such as equipment rooms or activity rooms	$L'_{nT,w} \leq 60 \text{ dB}$
Façade	Bedrooms	$D_{2m,nT,Atr} \geq 30 - 47 \text{ dB}^{(2)}$
	Living rooms	$D_{2m,nT,Atr} \geq 30 - 42 \text{ dB}^{(2)}$

⁽¹⁾ $D_{nT,A} \approx D_{nT,w} + C_{100-5000}$

⁽²⁾ $D_{2m,nT,Atr} \approx D_{2m,nT,w} + C_{tr100-5000}$. Façade sound insulation requirements depend on the value of L_d of the area the building is located.

⁽³⁾ A living unit is a part of a building used for a specific purpose, whose occupants are linked like a family, a corporation or any organization. The DB HR mentions various examples of living units such as dwellings, hospital rooms, hotel rooms, classrooms, etc. In this case, a living unit is a dwelling.

The Spanish Building Code allows a deviation of 3 dB between the requirements and the in situ test results for sound insulation, due to measurement uncertainties.

Table 2. Limit values for service and equipment noise in dwellings.

Type of spaces	Limit value ⁽¹⁾		
	$L_{K,d}$ (7:00-19:00)	$L_{K,e}$ (19:00-23:00)	$L_{K,n}$ (23:00-7:00)
Living rooms	$\leq 40 \text{ dB}$	$\leq 40 \text{ dB}$	$\leq 30 \text{ dB}$
Bedrooms	$\leq 35 \text{ dB}$	$\leq 35 \text{ dB}$	$\leq 25 \text{ dB}$

⁽¹⁾ Limit value $L_K = L_{A,eq} +$ corrections for background noise, tonal, impulsive and low frequency noise.

In addition, there are requirements for reverberation time in certain spaces, which are shown in Table 3. In the case of reverberation time tests, a tolerance of 0.1 s is allowed.

Table 3. Limit values for reverberation time and sound absorption in Spain.

Type of spaces	Limit value ⁽¹⁾
Classrooms and conference rooms up to 350 m ³	$T \leq 0.7 \text{ s}$ (empty classrooms)
	$T \leq 0.5 \text{ s}$ (with fixed furniture, e.g. fixed seats)
Restaurants	$T \leq 0.9 \text{ s}$
Corridors in hospitals, schools and hotels	$A \geq 0.2 \text{ m}^2/\text{m}^3$

3. BUILDING CONTROL IN SPAIN

In Spain, the Building Code regulates the technical requirements of the buildings at a national level. Part I of the Spanish Building Code[5] is a framework that also sets general conditions for the construction and maintenance of buildings and their facilities.

Permits and building control depend on autonomous communities and local governments. They set building permit procedures, including post construction ones. In Spain, after the completion of a building, the local authorities issue the “first occupation license”, a certificate of occupation that confirms that the building is safe and habitable and has been constructed in accordance with the the specifications that were submitted to the local authorities before the construction began.

The procedures involved in the “first occupation license” vary according to the local government. Spain is divided into 17 autonomous communities, and has 8,131 towns[6]. Several of them require pre-occupancy acoustic testing. Acoustic testing comprises airborne sound insulation of separating walls, floors and façades according to ISO 16283 [7], [8], [9], reverberation time according to ISO 3382 [10] and the sound pressure level of building services according to specific procedures in regional decrees and ordinances.

The regions and cities where pre-occupancy acoustic tests are mandatory are listed below with references to specific regional and local regulations. See Figure 1:

- Andalucía [11 - 12];
- Castilla y León [13];
- País Vasco [14 - 15];
- The cities of Barcelona [16], Murcia [17] and Valencia[18].

These areas have defined sampling procedures in their local regulations. Regions like Galicia[19] or Comunidad Valenciana[20] require pre-occupancy testing, but do not define the sampling procedures for acoustic testing, thus they are not included in this comparative study.



Figure 1. Areas where acoustic testing is mandatory in Spain and a sampling procedure is defined in regulations.

In most cases, the tests are mandatory for new build homes, and for building renovations, according to the scope of Basic document DB HR Protection against noise [2]. In Andalucía, tests are also required for retrofitting in which an essential variation of the facades or the whole structural system are planned or in the case of a material change of use.

Furthermore, to ensure control over these measurements, the autonomous communities specify requirements regarding acoustic tests, such as that these measurements be carried out by an accredited or collaborating company. This accreditation evaluates the activity of laboratories to ensure their impartiality and competence. Likewise, the quality departments of the different autonomous communities maintain a registry of competent entities for the performance of acoustic tests

In the rest of the regions of Spain, pre-completion sound testing is not mandatory, nevertheless, acoustics is often of great concern for builders and developers, who in some cases hire consultants to conduct acoustic performance tests to make sure regulations are met.

4. ACOUSTIC SAMPLING

4.1 Sound insulation

The following tables contain the minimum number of sound insulation tests to be carried out for each different constructive element: separating walls, floors or facades in different places mentioned in section 3.

In general, the most repeated criterion is to test at least 10% of the dwellings per each construction element: separating walls floors and facades, for airborne and impact sound insulation. However, there are differences, as some regions indicate to test the airborne sound insulation of at least 20% of the dwellings and in País Vasco, the procedure for pre-completion testing is described in more detail[15]. Tables 5, 6 and 7 describe the minimum mandatory tests to be carried out depending to the number of dwellings in País Vasco

Table 4. Minimum number of sound insulation tests that are mandatory in different cities and autonomous communities in Spain.

Place	Sound insulation between dwellings (separating walls and floors)		Façade
	Airborne	Impact	
Andalucía	20% [10%] ⁽¹⁾	10%	10%
Castilla y León	20%	10%	10%
País Vasco	See Table 5	See Table 6	See Table 7
Barcelona	MAX(10% n; \sqrt{n})+1		
Murcia	MAX(10% n; \sqrt{n})		
Valencia	MAX(10% n; \sqrt{n})		

n: number of dwellings

⁽¹⁾ Draft Decree approving the regulation for the preservation of acoustic quality in Andalucía. 2021. Still under revision.

Table 5. Minimum number of airborne sound insulation tests, $D_{nT,A}$, to be performed in País Vasco between any protected room inside a living unit (e.g., a dwelling), and any other room outside the living unit, excluding plant rooms and activity rooms.

n, (number of living units, e.g., dwellings)	Number of airborne sound insulation tests for adjacent rooms	
	Horizontally	Vertically
$n \leq 20$	1	1
Si $20 < n \leq 80$	2	2
Si $80 < n \leq 140$	3	3
Si $140 < n \leq 200$	4	4
Si $200 < n \leq 260$	5	5
Si $260 < n \leq 320$	6	6
Si $320 < n \leq 380$	7	7
Si $n \geq 380$	8	8

Table 6. Minimum number of impact sound insulation tests, $L'_{nT,w}$, to be performed in País Vasco between any protected room inside a living unit (e.g., a dwelling), and any other room outside the living unit, excluding plant rooms and activity rooms.

n, (number of living units, e.g., dwellings)	Number of impact sound insulation tests for adjacent rooms	
	Horizontally	Vertically
$n \leq 20$	1	1
$Si\ 20 < n \leq 80$	1	2
$Si\ 80 < n \leq 140$	1	3
$Si\ 140 < n \leq 200$	2	4
$Si\ 200 < n \leq 260$	2	5
$Si\ 260 < n \leq 320$	3	6
$Si\ 320 < n \leq 380$	3	7
$Si\ n \geq 380$	4	8

Table 7. Minimum number of façade sound insulation tests, $D_{2m,nT,Atr}$, to be carried out in País Vasco in protected rooms in a living unit, e.g., bedrooms and living rooms.

n, (number of living units, e.g., dwellings)	Number of tests for façade sound insulation
$n \leq 20$	1
$Si\ 20 < n \leq 80$	2
$Si\ 80 < n \leq 140$	3
$Si\ 140 < n \leq 200$	4
$Si\ 200 < n \leq 260$	5
$Si\ 260 < n \leq 300$	6
$Si\ 320 < n \leq 380$	7
$Si\ n \geq 380$	8

The information of the decrees and ordinances analysed is not homogeneous. In most cases, regulations provide a brief explanation of the construction elements to be tested and the percentage of sound insulation tests to be carried out, but in País Vasco there are criteria for prioritizing test cases, which is useful for consultants as it defines which rooms must be chosen first for in situ testing. In general, the priority is to select the worst cases, e.g., testing bedrooms adjacent to noisy rooms of other dwellings, such as bathrooms, kitchens and living rooms; selecting the reception rooms among those with the lowest ratio of V/S_s , where V is volume and S_s is the surface of the separating element or avoiding testing rooms separated by expansion joints.

Even there is some criteria for prioritizing façade sound insulation, e.g., choosing rooms on the most exposed façade, biggest openings and with the lowest ratio of V/S_F , where V is volume and S_F is the surface of the façade.

Regarding plant rooms or activity rooms¹ several regulations specify that all cases of plant rooms or activity adjacent to protected rooms, e.g. bedrooms and living rooms must be tested, either for airborne or impact sound insulation.

4.2 Sound pressure levels produced by service and equipment

Table 8 summarizes the approach to the sampling of sound pressure levels due to service and equipment in each autonomous community and city. Whenever the sound pressure levels from building services are required to be measured, the focus is on communal systems, except for plumbing noise. Individual building services such as individual HVAC, noise from bathrooms or individual mechanical ventilation with heat recovery are not required to be tested.

Table 8. Sampling for sound pressure levels for service and equipment noise.

Place	Tests required
Andalucía	All communal equipment must be tested, except drainage systems. For drainage downspouts and other wastewater facilities, acoustic measurements must be carried out in the most affected rooms, in the most unfavorable conditions.
Castilla y León	All communal equipment must be tested, except drainage systems. For drainage downspouts and other wastewater facilities, acoustic measurements must be carried out in the most affected rooms, in the most unfavorable conditions.
País Vasco	All communal equipment must be tested. For the following types of equipment, at least one test must be performed: <ul style="list-style-type: none"> mechanical ventilation, which comprises garage exhaust mechanical ventilation and mechanical ventilation in dwellings for comfort ventilation; electric garage doors; lift motor rooms; plant rooms: boiler rooms, heat pumps, HVAC, etc.
Barcelona	No acoustic test for service and equipment are required, except for lifts adjacent to rooms. Measurements are performed according to ISO 10052[21].

¹ Activity rooms are premises with an A-weighted sound pressure level up to a 70dBA. Leisure activity premises such bars, pubs, discos, workshops, etc. where the sound pressure level usually exceeds 70 dBA are considered “noisy premises”, and the DB HR does not apply to them. In that case, it is the local authority that sets the noise insulation requirements and this is related to the type of activity license.

Table 8. Sampling for sound pressure levels for service and equipment noise.

Place	Tests required
Murcia	No acoustic tests for service and equipment are required. Instead, the airborne and impact sound insulation of all construction elements which separate a dwelling and a plant room must be tested.
Valencia	No acoustic tests for service and equipment are required. Instead, the airborne and impact sound insulation of all construction elements which separate a dwelling and any type of equipment, like plant rooms, must be tested.

4.3 Reverberation time in classrooms and restaurants

Despite being a requirement in the Spanish Building Code[2], only Castilla y León requires reverberation time measurements in classrooms and conference rooms, restaurants and canteens.

4.4 The sampling procedure in the Spanish classification scheme

In Spain there is another sampling procedure defined in the acoustic classification standard UNE 74201[3], which was approved in September 2021. This standard is voluntary and contains two verification procedures that are based on field measurements; it establishes the necessary sampling for the different acoustic characteristics and some guidelines are given for the selection of construction elements to be tested considering the most unfavourable situations. This sampling procedure could be a reference for those places that do not have mandatory acoustic testing and do not define any sampling method.

The UNE 74201 standard is based on ISO TS 19488[22] and defines in great detail the verification and the following two sampling-plan procedures, intended to facilitate the implementation of this classification scheme:

- procedure A is based on verification by calculations, visual inspections and in situ tests, thus it implies the advice of an acoustician in the design, construction and inspection of a building;
- procedure B is based exclusively on in situ tests.

In relation to sound insulation, in general, the sampling rate defined is 5 or 3% for procedure A and 10 or 6% for procedure B (3 and 6% applies in some cases to vertical adjoining rooms to avoid a large number of resulting rooms to be tested). For those cases involving activities

or service equipment rooms, it is indispensable to test, at least, one case.

Unlike the decrees explained above these percentages apply to cases, not to the number of dwellings. Cases are given for the different acoustic characteristics and according to the type of rooms (protected, service equipment or activity rooms) and the relative position of adjoining rooms: vertically adjacent or horizontally adjacent. Subcases are related to different construction systems in each identified case.

Sampling is also defined for:

- reverberation time: at least one measurement per subcase;
- service equipment: all installations must be measured at least once;
- waste water installations: 1% of the detected cases (those with a change of direction in the pipe adjoining the protected room), with a minimum of one test;
- bathroom fittings (shower, lavatory, bidet, washbasin) and kitchen sinks: 1% of the vertically, 1% of the horizontally, 1% of the diagonally adjoining rooms, with a minimum of one test per each type of element.

Once the sampling method have been applied and the number of tests to be made is known, the standard defines some guidelines to help the technicians to select the specific rooms to be tested. These guidelines prioritize the most unfavourable situations applying criteria according to the type and use of the rooms first, and then geometric characteristics and other parameters. Other criteria for selecting rooms are no expansion joints, no coverings, higher values of outdoor noise, the size of the rooms or the proximity to noise sources.

5. CONCLUSIONS

Pre-occupancy acoustics testing plays an essential role in the acoustic quality of buildings, as it ensures the verification of requirements. In Spain, pre-occupancy acoustic testing is not mandatory at the national level, but several autonomous communities and local governments require testing the sound insulation before the completion of buildings to obtain the “first occupancy license”, which is a completion certificate issued by the authorities that confirms that the building is safe and habitable.

This paper is a comparative study on the different sampling procedures and of regional decrees and ordinances in Spain which require mandatory acoustic testing. It also includes the sampling procedure in the Spanish acoustic classification scheme, which could be a reference for those places that do not have mandatory acoustic testing and do not define any sampling method.

In all the communities and municipalities analyzed, sound insulation measurements are required in dwellings for the following cases:

- airborne and impact noise between dwellings;
- façade sound insulation;
- airborne and impact sound insulation between dwellings and plant rooms or activity rooms.

Each autonomous community specifies the criteria on sampling. The most repeated criterion is to test at least 10% of the dwellings per each construction element: separating walls floors and facades, for airborne and impact sound insulation, but there are differences, as some regions indicate to test the airborne sound insulation of at least 20% of the dwellings and in País Vasco, the procedure for pre-completion testing is described in more detail[15].

Regarding the noise levels produced by building services, there are different approaches. In some places, Barcelona, Murcia and Valencia, it is not required to test the sound pressure levels from building services. In the rest of the autonomous communities, all communal building services affecting adjacent dwellings must be tested. Individual systems, such as HVAC heat pumps, water installations or mechanical ventilation are not required to be tested².

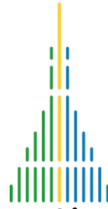
The information contained in regional decrees and ordinances is not homogenous. In some places local governments have developed guidelines and documents [15], [23-24] to help acousticians to apply regulations. Nevertheless, it would be convenient for acousticians and professionals if criteria and sampling procedures were harmonized in all regions of Spain.

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² Except for País Vasco, where mechanical ventilation of dwellings must be tested.

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