ANALYSIS OF THE DRAFT SPANISH STANDARD PNE UNE 74201: ACOUSTIC CLASSIFICATION SCHEME FOR BUILDINGS

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ABSTRACT

The objective of an Acoustic Classification Scheme (ACS) for buildings is to specify different quality levels for buildings related to its acoustic performance. The Spanish standardisation building acoustics committee, through its corresponding working group CTN 74/SC2/GT1, has been working in the recent years on the development of an ACS compatible with Spanish building acoustics regulations and based on ISO/NP TS 19488. Recently the consensus of the latest draft revision has been reached and the standard is to be processed by the Spanish standardisation body UNE.

The ACS includes criteria for airborne, impact and façade sound insulation, for service equipment noise and for reverberation time. This paper analyses the contents of PNE UNE 74201 draft and the most troublesome issues within it, including a discussion on the assigned values and alternative procedures for verification of compliance.

1. INTRODUCTION

Acoustic regulations in Spain contained in the DB HR framework [1] include airborne, impact and façade sound insulation requirements. There are also requirements for reverberation time in some cases and some indications regarding service and equipment noise in accordance with the noise law [2, 3]. The basic requirements in DB HR are a minimum airborne sound insulation of $D_{nT,A}$ ($\approx D_{nT,w}+C_{100\text{-}5000}$) $\geq$ 50 dBA and a maximum impact sound insulation of $L'_{nT,w}$ $\leq$ 65 dB between two adjoining dwellings. As for the façades, the required sound insulation $D_{2m,nT,Atr}$ ($\approx D_{2m,nT,w}+C_{100\text{-}5000}$) ranges from 30 to 42 dBA, depending on the use of the building and on the exterior noise levels.

In general, building acoustics regulations specify minimum requirements that guarantee a certain level of acoustic quality for new buildings, but do not always ensure satisfactory conditions for its occupants. There are different research works based on social surveys and laboratory experiments from which it has been possible to extract relationships between the acoustic performance of the building and the expected percentage of people who find satisfactory acoustic conditions [4]. Therefore, it can be estimated that only 40% of residential building occupants are satisfied with acoustic conditions when typical requirements for airborne and impact noise insulation established in European regulations are applied. Considering this insufficient percentage, many countries have introduced acoustic classification systems (ACS) whose highest classes would correspond to 60% or 80% of satisfied occupants.

An ACS defines a number of classes reflecting different levels of quality for the acoustic conditions of buildings. There is a great potential to achieve enhanced acoustic insulations above regulatory values and an ACS can be an incentive for the improvement of the acoustic quality of the building, and it is an idea that is becoming widespread in the countries around us. There are already 13 existing national acoustic classification schemes in Europe for dwellings [5].

In Spain, the experience has shown that most of buildings constructed under the DB HR regulations meet the sound insulation requirements without problem; moreover, it is very possible and feasible to obtain acoustic performance above the requirements, with more or less margin depending on the construction system and the acoustic characteristic considered, airborne or impact sound insulation [6]; some examples can be found in [7].

In view of this scenario, both the building sector and product manufacturers asked the building acoustics committee CTN 74 from the Spanish Standardisation Board to develop an acoustic classification scheme for buildings compatible with DB HR and a working group (GT1) was established to do it.

As of March 2020, the last aspects of the drafting of the standard are being reviewed, before it can be processed by the Spanish Standardisation body UNE.

The ACS includes criteria for airborne, impact and façade sound insulation, for service equipment noise and for reverberation time. This paper analyses the contents of PNE UNE 74201 draft [8] and the most troublesome issues within it, including assigned values, alternative procedures for verification of compliance and an application example.

2. BACKGROUND

The need for harmonization of sound insulation descriptors in Europe is clearly presented in [4, 9]. In 2008, an initiative towards harmonization led to the establishment of the European Action COST TU0901

(2009-2013) [10] with members from 32 countries and with two main objectives: to propose building acoustic descriptors and to develop a European acoustic classification scheme for dwellings.

As a result, a project for an international acoustic classification scheme for dwellings [11] was drafted, which was subsequently proposed as a new work item proposal in ISO/TC43/SC2 to develop an ISO Acoustic Classification Scheme (WG 29) [12]. As of today, following the advice of ISO and many WG 29 experts, it was decided to propose the Acoustic Classification Scheme as an ISO Technical Specification (TS) instead (ISO/NP TS 19488) [13]; this proposal was approved in March 2019.

The working group created in Spain, within the structure of AENOR CTN 74/SC2, with the objective of developing an acoustic classification scheme, used these COST and ISO standard proposal as a starting point, but seeking compatibility with DB HR regulations as much as possible.

The members of this group are experts from different sectors such as product manufacturers, laboratories, universities, building research institutes and administration. It started to work in October 2016.

At the beginning, the adaptation of the Spanish ACS to DB HR regulations was sought, in terms of frequency margins, descriptors, definitions, scope, etc. but tending to converge with the ISO scheme. It was also intended to define sampling criteria and to unify selection criteria for test rooms within the building. As the work progressed, differences from ISO ACS proposal emerged, for instance, using DB HR descriptors and frequency margin, establishment of class D for regulatory values and defining a new class F for those cases in which the acoustic performance is below a certain value, so that the existing building cases are considered.

3. PNE UNE 74201 SCOPE

The scope of the standard has been expanded with respect to ISO/NP TS 19488 to apply to private and public residential buildings, whether they have several flats or they are detached and attached dwelling houses, and for hospital and health buildings and educational use as well.

In the Spanish scheme draft criteria for 6 acoustic classes are specified (A, B, C, D, E and F - A is the upper and F is the lower class). Buildings complying with the limit values of the DB HR are class D and buildings with acoustic performance below a certain value would correspond with class F, which is intended to classify existing buildings.

If a certain acoustic performance is not determined or is not applicable, the indication “npd” (no performance determined) is included.

The Spanish ACS proposal includes criteria for airborne, impact and façade sound insulation, for service equipment noise and for reverberation time. In relation to reverberation time the scope is limited to public residential buildings, educational and hospital/health buildings.

This ACS can be applied to an entire building, an individual dwelling, a specific room or even a specific acoustic characteristic.

4. IMPORTANT NORMATIVE REFERENCES

The Spanish building code has recently been updated [14] and testing standard ISO 16283 [15-17] has been included. The Spanish ACS proposal indicates that the standard ISO 16283 must be used for sound insulation measurements.

Another normative aspect to highlight is that ISO 16032 standard is indicated for service equipment noise levels measurements. Although initially it was stated that both measurement methods [18, 19] could be used, since this could be confusing, it was decided to keep only ISO 16032 measurement method to assure the results repeatability and accuracy. Before making a decision, an analysis of both ISO standards was made [6], in comparison with Spanish noise law [2].

Theoretical calculations according to ISO 12354 [20] can be used in the design stage of a building.

5. ASSIGNED VALUES TO THE CLASSES FOR EACH OF THE ACOUSTIC CHARACTERISTICS

Assigned values to the classes had to be adjusted in the Spanish scheme in comparison with those in the ISO scheme. Otherwise, the scheme would not be very applicable in the Spanish building sector. Within these settings class D was defined for requirements in DB HR and all situations with acoustic performance below a certain value were included in the lower class F.

Assigned values for different acoustic characteristics are shown in the following sections.

IMPORTANT: Please note that the values shown in this paper are subject to a final revision of the standard before it is published by the Spanish Standardisation body UNE.

Type of rooms	Class A	Class B	Class C	Class D	Class E	Class F
Between protected rooms and other rooms, both in the horizontal and the vertical directions	$D_{nT,A} \geq 60$	$D_{nT,A} \geq 57$	$D_{nT,A} \geq 54$	$D_{nT,A} \geq 50$	$D_{nT,A} \geq 46$	$D_{nT,A} < 46$
Between protected rooms and service equipment or activity rooms	$D_{nT,A} \geq 65$	$D_{nT,A} \geq 62$	$D_{nT,A} \geq 59$	$D_{nT,A} \geq 55$	$D_{nT,A} \geq 51$	$D_{nT,A} < 51$
Between protected rooms and common or access areas with an entrance door in the separating wall	$D_{nT,A} \geq 40$	$D_{nT,A} \geq 37$	$D_{nT,A} \geq 34$	$D_{nT,A} \geq 30$	$D_{nT,A} \geq 28$	$D_{nT,A} <28$
Note: Elevator shafts will not be included as facilities.						

Table 1. Airborne sound insulation between protected rooms and other rooms. Class limits.

5.1 Airborne sound insulation

Table 1 shows the minimum values for airborne sound insulation for each of the classes.

5.2 Impact sound insulation

Table 2 shows the maximum values for impact sound pressure level for each of the classes.

Type of rooms	Class A	Class B	Class C	Class D	Class E	Class F
In protected rooms from other rooms or common access areas both in the horizontal and the vertical directions	$L'_{nT,w} \leq 47$	$L'_{nT,w} \leq 53$	$L'_{nT,w} \leq 59$	$L'_{nT,w} \leq 65$	$L'_{nT,w} \leq 70$	$L'_{nT,w} > 70$
In protected rooms from service equipment or activity rooms	$L'_{nT,w} \leq 42$	$L'_{nT,w} \leq 48$	$L'_{nT,w} \leq 54$	$L'_{nT,w} \leq 60$	$L'_{nT,w} \leq 65$	$L'_{nT,w} > 65$

Table 2. Impact sound pressure levels between protected rooms and other rooms. Class limits.

5.3 Sound insulation against exterior noise

Sound levels indoors depend highly on the outdoor source and sound insulation.

Table 3 shows the minimum values for sound insulation for a specific environment characterised by L_d for the relevant outdoor sound sources, for each of the classes.

Type of rooms	Class A	Class B	Class C	Class D	Class E	Class F
Façades, roofs and floors in contact with exterior air in protected rooms; in specific environment with sound sources characterised by L_d	$D_{2m,nT,Atr} \geq L_d-21$	$D_{2m,nT,Atr} \geq L_d-24$	$D_{2m,nT,Atr} \geq L_d-27$	$D_{2m,nT,Atr} \geq L_d-30$	$D_{2m,nT,Atr} \geq L_d-34$	$D_{2m,nT,Atr} < L_d-34$
Notes: In the case of predominant aircraft noise, L_d + 4 dBA should be considered. In any case, classes A, B, C and D additionally require compliance with the insulation levels required in the DBHR.						

Table 3. Sound insulation against exterior noise. Class limits.

5.4 Noise from building service equipment

DB HR does not include any limit to service and equipment noise; it refers to another law: "Ley 37/2003 del Ruido" (Noise Law) [2], and more specifically, to a complementary decree, RD 1367/2007 [3], which contains the limit values for sound pressure levels due to service equipment noise, as well as the measurement and evaluation procedures. These procedures are different from those contained in ISO 16032 used for classification. Therefore, it was agreed to make this explanatory note: "*the classification obtained does not imply compliance with RD 1367/2007 since the test method is different.*"

Table 4 shows maximum values for A-weighted time-averaged or the maximum sound pressure levels due to service equipment, for each of the classes.

Type of room and sources	Quantity	Class A	Class B	Class C	Class D	Class E	Class F
In protected rooms from outdoor and indoor service equipment producing continuous noise in adjacent rooms.	$L_{A,eq,nT}$	≤ 24	≤ 27	≤ 30	≤ 33	≤ 36	> 36
In protected rooms from outdoor and indoor service equipment producing intermittent or irregular noise in adjacent rooms.	$L_{AF,max,nT}$	≤ 28	≤ 31	≤ 34	≤ 37	≤ 40	> 40

Table 4. Sound pressure levels in protected rooms due to building service equipment. Class limits.

The requirements for sound pressure level from service equipment apply to equipment serving the whole building and to noise from the use of sanitary systems. For individual service equipments, they must be tested and reported only if such equipment is operative when performing the measurements. If the equipment exists but is not yet operative, it shall be reported in the corresponding certificate.

5.5 Reverberation time in classrooms and common access areas

Reverberation time values only apply to public residential, health and educational uses. In this case, compliance with the DB-HR is established as class A, given the precision of the measurements.

Table 5 shows the maximum values allowed for the reverberation time in empty and unoccupied rooms for each of the classes. These values only apply to public residential, health and teaching uses.

Type of room	Class A	Class B	Class C	Class D	Class E	Class F
In common access areas sharing an entrance door with protected rooms	≤ 0,6 s	≤ 0,9 s	≤ 1,2 s	≤ 1,5 s	≤ 1,8 s	> 1,8 s
Empty classrooms	≤ 0,7 s	-	-	0,7 <T ≤ 1,0 s	-	> 1,0 s
Empty canteens and restaurants	≤ 0,9 s	-	-	0,9 <T ≤ 1,2 s	-	> 1,2 s

Table 5. Reverberation time. Class limits.

6. DISCUSSION ON THE MOST TROUBLESOME ISSUES

During the development work of the Spanish ACS there have been some troublesome points where discussion has been necessary to analyse different points of view and to reach a consensus of the best possible solution. The most interesting discussion points are discussed below.

6.1 Façade class limits

Existing requirements in DB HR for the protection against outdoor noise are related to L_d values, and thus this same criteria applies to the class limits in the ACS.

Since these requirements depend not only on the outdoor noise but also on the use of the rooms and of the building as well, it was difficult to adjust the values in Table 3 because different combinations of values solved some aspects but other different problems arose. While discussing which values where the best to define each class limit, the main objections found were:

- The DB HR requirements were not met in some circumstances or when met they fell into class E;
- Very high façade insulations are required to achieve class A in $65 < L_d \leq 70$ dBA areas; this could also condition the overall final classification results of the building since it would be difficult to get global buildings certifications of classes A or B, what could discourage constructors to use the ACS and confuse end users;
- On the other hand, decreasing the requirements could mean class B or C classifications with poor façade insulation values even with no requirements compliance.

Finally, the proposed values take into consideration that it is not so difficult to achieve classes A or B in $L_d \leq 65$ dBA areas; and, aiming at improving buildings acoustic quality, if someone wants to be class A in a very noisy area, they will have to make a strong commitment to improve the insulation of the façade what would be a way to encourage improvement on what is currently being built.

6.2 Service and equipment noise

As previously discussed, a measurement method compatible with the Noise Law had to be selected and ISO 16032 was chosen.

Another important problem that the working group found for installations noise classification was considering whether collective or individual facilities were considered. On the one hand, it is often not possible to measure the individual installations (mainly cooling and heating installations) before the dwelling occupation; sometimes they are not even installed; and on the other, there are many individual installations (such as sanitary appliances) that produce great noise nuisance among neighbours.

Finally, it was agreed that in those facilities where it is not clear whether they will be tested or not, it should be specifically reflected in the building certificate report which of them are in/out of the scope of the classification report. On the other hand, it is considered that the sanitary appliances (such as shower, bath, cistern, etc.) can be tested with construction on site water and therefore must be considered in service and equipment noise classification. Criteria for sanitary appliances are still being discussed.

From this last decision, another problem arises related to the sanitary appliances cases to be considered in a building and in the sampling plan so that the number considered is not excessive but is sufficiently representative.

6.3 Criteria for assigning classes

A very important part of this scheme is how the assignment of classes is made from the results of the tests and how the expression of results is done. In this sense it has been necessary to define criteria for significant figures and rounding.

In relation to the criteria for assigning classes, it was agreed to establish a 2 dB tolerance for individual results to be assigned to a certain class provided that the arithmetic average of the results (without considering the uncertainty) complies with the corresponding class limit. In the case of reverberation time, this tolerance is 0,1 seconds.

Regarding the rounding of the final result of the classification and the individual results of each measurement, it was decided that, in each case, the arithmetic average will be calculated taking the results of the tests and subsequently rounding the arithmetic average to the unit.

6.4 Verification and sampling plan procedure

This has been the most troublesome point to discuss within the working group. The challenge was to design simple enough guidelines to encourage the use of the standard and, in turn, to define a statistically representative sampling procedure and with such level of detail that, if two different entities apply it, they both get the same classification results.

Most of the work was in defining the criteria to identify all the possible cases that could occur in a building and that would have to be taken into account, as well as the hierarchy or priority of each of them to be selected as test cases, taking into account the type and use of the rooms, geometric criteria or other general criteria.

In relation to the quantification of the number of tests to be carried out, the initially proposed percentages (5% for procedure A and 10% for procedure B[1]) had to be reduced (3% and 6% respectively) for some cases due to the large number of resulting rooms to be tested.

6.5 Technical competence to apply the ACS

Another point of discussion of difficult agreement has been whether the standard should include requirements regarding the qualification of the entities or technical personnel that carry out the classification. The staff will perform important technical tasks such as selecting the verification procedure, addressing sensitive questions at the design stage, estimating the sound insulation, approaching the sampling plan for the measurements and, possibly, making the measurements themselves.

Although there is a general agreement that technical solvency is absolutely necessary at all stages of the classification procedure, it seems that this type of standard should not include references relative to how to prove the technical solvency, so the document will not include any hint on how to prove this technical solvency.

7. VERIFICATION AND SAMPLING PROCEDURE. EXAMPLE OF APPLICATION.

The classification scheme can be applied to an entire building, an individual dwelling, a specific room or even a specific acoustic characteristic. To obtain a certain class assignment, all the acoustic characteristics of application must comply with, at least, the assigned class. The dwellings in a building can be assigned to different classes.

The guidelines for the verification procedure have been structured in sequential steps, which have already been explained in previous works [6]. Therefore, in this paper the verification and sampling procedure will be exposed through a real application example.

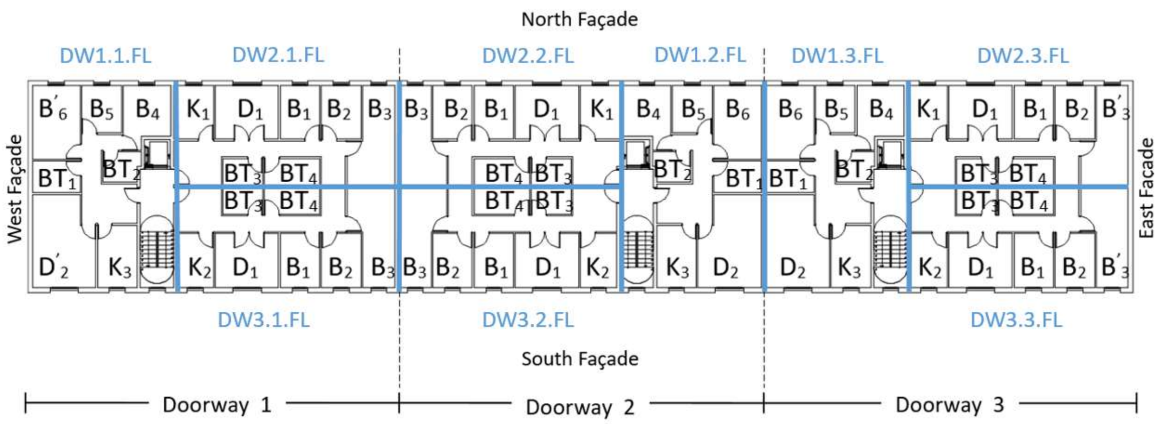
7.1 Building description

A private residential building of 6 heights, with 3 doorways and 9 dwellings per floor, with an arrangement according to figures 1-3 is used for this example. The dwellings take up the 1st to 5th floors. There is no expansion joint between rooms belonging to different use units (dwellings).

In relation to service equipment or activity spaces:

- In the ground floor there is a collective garage, with an automatic access door, and a boiler room;
- Each doorway has a lift that has integrated machinery;
- The constructive solutions in the rooms comply with:
- They are all of the same typology except in separating walls between kitchen and bedroom;
- As for the façades, the windows have the same composition for all protected rooms; the same size in all bedrooms and they are larger in living rooms. There are no balconies in any protected room.

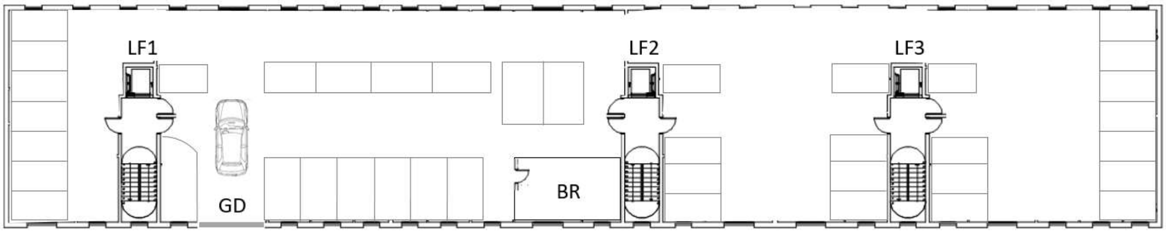
The building is exposed to the same day noise level (L_d) in its three north, east and west façades but a higher value in the case of the south façade.



Legend:
B: Bedroom D: Dining room BT: Bathroom K: Kitchen
DW1: Dwelling 1 DW2: Dwelling 2 DW3: Dwelling 3
Example: DW2.1.4 is DW2 in doorway 1 in the 4th floor.

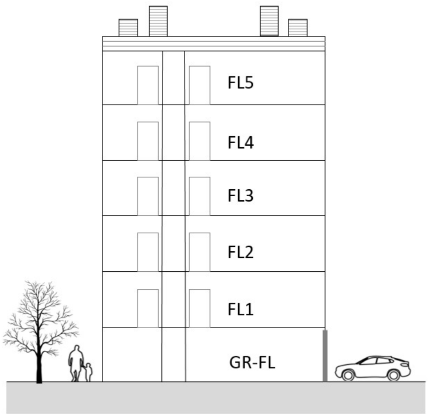
Figure 1. Plan layout of the building. Pattern plant: 1st to 5th floors.

[1] The same as ISO proposal [12], the Spanish ACS draft includes two procedures to be applied: procedure A based on verification by calculations, visual inspections and field measurements; and procedure B based on field measurements only.



Legend:
LF1: Lift in doorway 1
LF2: Lift in doorway 2
LF3: Lift in doorway 3
GD: Garage door
BR: Boiler room

Figure 2. Plan layout of the building. Ground floor: Garage and service equipment.



Legend:
FL1 to FL5: 1st to 5th floors (dwellings)
GR-FL: Ground Floor (garage and service equipment)

Figure 3. Elevation of the building.

7.2 Identification of cases and subcases

First, we have to identify all different protected rooms existing in the building. These rooms are bedrooms (3 per dwelling) and dining rooms (1 per dwelling). There are a total of 36 protected rooms per floor.

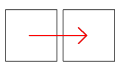
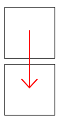
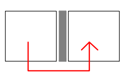
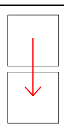
Then we have to look for different adjoining rooms to these protected rooms and identify different cases, according to Table 6.

In this example, cases C01, C04, C05, C06, C08, C10 and C11 have been identified. There are no C03, C07, C09 cases. Reverberation time cases are not applicable to a private residential building (C12, C13 and C14).

Next, we have to identify the different subcases related to different construction systems for each identified case. In this way, C01-1 and C01-2 subcases are identified (bedroom/bedroom and dining room/dining room have the same construction system but bedroom/kitchen has a different one).

As for different types of service equipment, subcases C11-1, C11-2 and C11-3 are identified for lifts, garage door and boiler room respectively.

Sanitary appliances cases in C11 are not considered in this example since the criteria for their consideration in the sampling plan are still under discussion.

Acoustic characteristic	Possible cases	
Airborne sound insulation		**C01:** Protected rooms horizontally adjacent to other rooms that are not service equipment or activity
		C02: Protected rooms horizontally adjacent to service equipment or activity rooms
		C03: Protected rooms adjacent to common or access areas with an entrance door in the separating wall
		**C04:** Protected rooms vertically adjacent to other rooms that are not service equipment or activity
		C05: Protected rooms vertically adjacent to service equipment or activity rooms
Impact sound insulation		**C06:** Protected rooms horizontally adjacent to other rooms that are not service equipment or activity
		C07: Protected rooms horizontally adjacent to service equipment or activity rooms
		**C08:** Protected rooms vertically adjacent to other rooms that are not service equipment or activity
		C09: Protected rooms vertically adjacent to service equipment or activity rooms

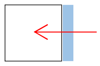
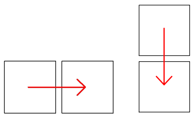
Acoustic characteristic	Possible cases	
Sound insulation against exterior noise		**C10:** Façades in protected rooms
Noise from building service equipment		**C11:** Service equipment rooms horizontally or vertically adjacent to protected rooms
Reverberation time	**C12:** Common access areas sharing an entrance door with protected rooms	
	C13: Empty classrooms	
	C14: Empty canteens and restaurants	

Table 6. Identification of possible cases.

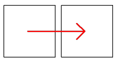
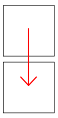
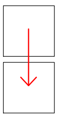
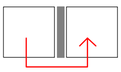
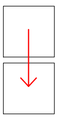
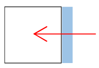
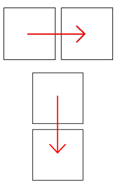
Acoustic characteristic	Cases	Subcases	No. rooms	Procedure A sampling	Procedure B sampling
Airborne sound insulation	C01 	C01-1: Bedrooom/Kitchen	15	1	2
		C01-2: Bedroom/Bedroom Dining room/Dining room	35	2	4
	C04 	C04: Bedroom/Bedroom Dining room/Dining room	144	5	9
	C05 	C05-1: Bedroom/Garage Dining room/Garage	35	2	4
		C05-2: Dining room/Boiler room	1	1	1
Impact sound insulation	C06 	C06: Bedrooom/Kitchen Bedroom/Bedroom Dining room/Dining room	50	3	5
	C08 	C08: Bedroom/Bedroom Dining room/Dining room	144	5	9
Sound insulation against exterior noise	C10 	C10: Bedroom/exterior Dining room/exterior	180	9	18
Noise from building service equipment	C11 	C11-1: Lift1/Bedroom Lift2/Bedroom Lift3/Bedroom	15	3	3
		C11-2: Garage door/Dining room	1	1	1
		C11-3: Boiler room/Dining room	1	1	1

Table 7. Summary of cases, subcases, No. rooms and sampling in the example studied.

7.3 Identification of the number of rooms per subcase

To count the number of rooms for each subcase, it must be taken into account that:

- There are 5 floors with dwellings, with a total of 36 protected rooms in each floor;
- On each floor, there are different horizontally adjoining dwellings in 9 occasions;
- All the protected rooms of the dwellings are outward facing;
- It is indispensable that all the activities/service equipment premises are tested in, at least, one case.

7.4 Quantification of sampling according to the verification procedure selected

As previously discussed, there are two different procedures for the verification of compliance with the criteria for an acoustic class: procedure A based on verification by calculations, visual inspections and field measurements; and procedure B based on field measurements only.

The sampling to be applied in each option is:

- Procedure A:
  - 5% of rooms identified corresponding to C01, C02, C03, C05, C06, C07, C09 y C10;
  - 3% of rooms identified corresponding to C04 y C08;
  - 5% of rooms identified corresponding to C12, C13 y C14;
- Procedure B:
  - 10% of rooms identified corresponding to C01, C02, C03, C05, C06, C07, C09 y C10;
  - 6% of rooms identified corresponding to C04 y C08;
  - 10% of rooms identified corresponding to C12, C13 y C14;
- For both procedures, A and B:
  - In cases C02, C05, C07 and C09, it is indispensable that all the activities/service equipment premises are tested in, at least, one case;
  - In cases C11, at least one test will be made for one vertically adjoining and another horizontally adjoining room, if applicable, for each installation;
  - In cases C11, given more than one common building facility of the same type (lifts, for instance), at least one measurement will be made for each of them.

The number obtained by applying these percentages will be rounded to the highest integer.

Table 7 summarizes the cases, subcases, total number of rooms and final number of rooms to be tested resulting from the sampling procedure.

7.5 Criteria for the selection of the rooms to be tested. Sound insulation

Criteria for the selection of the rooms to be tested are applicable for both procedures A and B. Most of the tests to be carried out are sound insulation tests (airborne, impact and façades), that is, cases C01 to C10. For these cases the first criterion to apply is the type of the receiving room and the adjoining emitting room in order to prioritise the most acoustically unfavourable cases according to table 8.

For each of the subcases, combinations of rooms will be sequentially selected from table 8. As many combinations as necessary will be selected to complete the number of tests obtained in the sampling procedure.

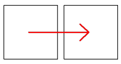
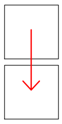
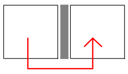
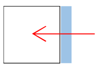
Use of the building	Selection order	Protected receiving room	Adjoining emitting room			
			Adjacent dwelling	Activity/service equipment premises	Common or access areas	Outside
			C01, C04 C06, C08	C02, C05 C07, C09	C03	C10
Private residential (housing)	1st	Bedroom	Kitchen	Activity/service equipment	Common or access areas	Outside
	2nd		Dining room			
	3rd		Bedroom			
	4th	Dining room	Kitchen			
	5th		Dining room			

Table 8. Room selection order.

Next, to specifically select the rooms to be tested, the general and the geometric criteria are applied:

- General criteria: Priority cases are those with no expansion joint in separating walls, with no elastic coverings like rugs and carpets in separating floors and for façades those cases in lower floors, without balconies, and with higher value of L_d;
- Geometric criteria: Priority cases are those with lower volume/surface ratio and for façades those with higher windows ratio.

In this example, the room selection is going to be done for verification procedure A, for cases C01, C04, C06 and C10 (see Tab. 9).

Cases	Subcases	Procedure A sampling	Rooms to be tested		
			Order	Receiving room	Emitting room
Airborne sound insulation C01  C04 	C01-1: Bedrooom/Kitchen	1	1st	B4 in DW1.1.1	K1 in DW2.1.1
	C01-2: Bedroom/Bedroom Dining room/Dining room	2	1st	B3 in DW2.1.2	B3 in DW2.2.2
			2nd	D2 in DW1.2.3	D2 in DW1.3.3
	C04: Bedroom/Bedroom Dining room/Dining room	5	1st	B6 in DW1.3.1	B6 in DW1.3.2
			2nd	D2 in DW1.2.2	D2 in DW1.2.3
			3rd	B3 inDW2.1.3	B3 in DW2.1.4
			4th	D1 in DW3.2.1	D1 in DW3.2.2
			5th	B2 in DW2.3.4	B2 in DW2.3.5
Impact sound insulation C06 	C06: Bedrooom/Kitchen Bedroom/Bedroom Dining room/Dining room	3	1st	B4 in DW1.3.4	K1 in DW2.3.4
			2nd	B3 in DW2.1.5	B3 in DW2.2.5
			3rd	D2 in DW1.2.2	D2 in DW1.3.2
Sound insulation against exterior noise C10(1) 	C10: Bedroom/exterior Dining room/exterior	9	1st	B3 in DW 3.1.1	Outside South façade
			2nd	D1 in DW 3.1.1	
			3rd	B3 in DW3.2.1	
			4th	D1 in DW3.2.1	
			5th	B1 in DW3.3.1	
			6th	D2 in DW1.2.1	
			7th	B3 in DW2.1.1	Outside North façade
			8th	D1 in DW2.2.1	
			9th	B5 in DW1.3.1	

(1) Although the façade most exposed to noise, with the highest L_d, is the south façade, it has also been preferred to do some measurements on the north façade, though to a lesser extent, to broaden the representativeness of the sampling.

Table 9. Selection order of rooms to be tested. Sound insulation.

7.6 Additional criteria for noise from building service equipment and for reverberation time

Additional criteria are given for noise from service equipment (C11) and for reverberation time (C12 to C14).

In case of service equipment noise, the test rooms will initially be selected following the order established in table 8 and selecting the protected rooms closest to the main sound sources. Cases with expansion joints should be avoided.

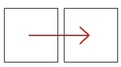
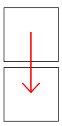
Cases	Subcases	Procedure A sampling	Rooms to be tested	
			Receiving room	Sound source
Noise from building service equipment C11  	C11-1: Lift1/Bedroom Lift2/Bedroom Lift3/Bedroom	3	B4 in DW1.1.1	Lift 1
			B4 in DW1.2.2	Lift 2
			B4 in DW1.3.4	Lift 3
	C11-2: Garage door/Dining room	1	D1 in DW3.1.1	Garage door
	C11-3: Boiler room/Dining room	1	D1 in DW 3.2.1	Boiler room

Table 10. Selection order of rooms to be tested. Noise from building service equipment.

In reverberation time cases, the highest volume rooms will be selected first. There are no cases of reverberation time in our example.

As for C11 cases in our example, the rooms to be tested are shown in table 10.

7.7 Criteria for assigning classes

Class assignment is done sequentially according to the following steps:

- Class assignment to each of the identified cases, following the indications in section 6.3;
- Class assignment to each of the acoustic characteristics: The class assignment for an acoustic characteristic is done based on the worst class result of the corresponding cases. In our example, to classify the acoustic characteristic "airborne sound insulation between rooms", one should assign the worst result obtained within cases C-01 and C-04;
- Class assignment to a complete dwelling or building: The classification of a complete dwelling or building will be the same as the most unfavourable acoustic characteristic in that dwelling or building.

8. CONCLUSIONS

This paper has exposed the proposed Acoustic Classification System (ACS) developed in Spain for building of different uses (public or private residential, hospital and health buildings and educational as well). This scheme, which in its beginnings it started and was based on the ISO scheme is compatible with the Spanish Acoustic Building Code (DB HR).

At the date of writing this paper, the PNE UNE 74201 draft is in its final stage but has not yet been sent to the Spanish standardisation body UNE for processing; It is our hope that when this paper is exposed, the standard has already passed the process and is about to be published.

The ACS includes criteria for airborne, impact and façade sound insulation, for service equipment noise and for reverberation time.

The contents of PNE UNE 74201 draft and the most troublesome issues within it have been analysed, explaining those key aspects that have required an additional effort and discussion for its development and to reach a consensus among the group of experts.

Moreover, an application example has been developed through which the verification procedures has been explained in a practical way.

The development of the ACS has been a work carried out, for several years and in an altruistic way, by experts from different sectors related to building acoustics (manufacturers, laboratories, universities, building research institutes, etc.)

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