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Acoustic treatment for a radio studio at the Escola Politècnica Superior de Gandia (Polytechnic School of Gandia)

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Abstract

When designing the acoustic treatment of a radio studio, it is critical to meet all acoustic requirements. On the one hand, there is the requirement for a very high acoustic insulation in the two rooms of the radio studio (studio room and control room), in order to achieve the recommended background SPL for this type of studios. On the other hand, there is the acoustic conditioning, to ensure that the appropriate acoustic quality parameters are achieved.
This work presents the acoustic treatment that has been implemented in the radio studio of the Escola Politècnica Superior de Gandia. To achieve both objectives, a multi-layer product has been used, consisting of a textile felt with low porosity, thermally bonded to a viscoelastic sheet and finally a perforated panel. In this way, two problems are solved with one treatment.

Keywords: acoustic insulation to airborne noise, acoustic conditioning, radio, acoustic requirements, vertical partition.

1 Introduction

This project aims to adapt two adjoining rooms located on the top floor of a tower in the Escola Politècnica Superior de Gandia, to function as a radio studio. The floor plan of the building showing the location of each of the rooms is presented in Figure 1.

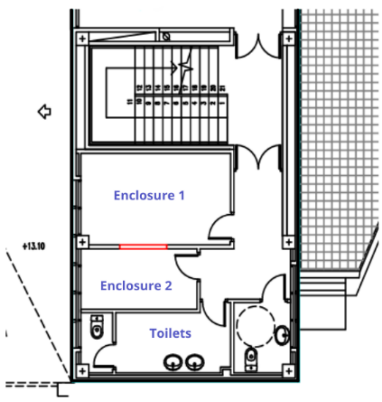

Figure 1 – Building floor plans with the enclosures under study

Enclosure 1 is intended to be used as a Studio room (Figure 2) and enclosure 2 as a Control room (Figure 3).

Studio Room

Volume = 32 m^3

Total area = 63 m^2

Floor area = 13 m^2

Figure 2 – Enclosure 1, intended to be the Studio Room

Control room

Volume = 15,3 m^3

Total area = 39 m^2

Floor area = 6 m^2

Figure 3 – Enclosure 2, intended to be Control Room

The conditions are very unfavourable, as both rooms are very small. In addition, they are located under the roof where the air-conditioning motors and other machinery are intalled. In other words, it receives a large amount of noise from both vertical and horizontal partitions.
Therefore, an acoustic solution is sought that satisfies the conditioning of the enclosures for the radio function, and at the same time isolate the walls and ceilings to comply with the DB-HR [1], which is the Basic Document for Noise Protection, part of the Spanish Technical Building Code, published by the Spanish government.
This work consists of two stages. The first is to analyze and diagnose the initial conditions of the enclosures. The second is to investigate a solution that meets the defined objectives that are presented in the next section.

2 Initial conditions

The first step was to find out the initial state of the enclosures, for which two types of studies were carried out. On the one hand, the acoustic conditioning was evaluated by measuring the reverberation time and the impulse response of the rooms, following the ISO 3382-2 standard [2]. In addition, the impulse response was used to calculate the typical acoustic quality parameters.
On the other hand, the airborne sound insulation of three vertical partitions was evaluated, according to the ISO 16283-1 standard [3]. While for the evaluation of the data obtained, the ISO 717-1 [4] standard was followed. The vertical partitions were measured as follows:

- Vertical partition containing the viewfinder: Enclosure 1 is taken as the transmitter and Enclosure 2 as the receiver, the transmission procedure being from the enclosure with the largest volume to the one with the smallest volume, as specified in the standard.
- Vertical patition between the stairs and Enclosure 1: the corridor stairs are studied as the emitting enclosure, and Enclosure 1 as the receiving enclosure. On this occasion, it is carried out from the small enclosure to the large one, contrary to what is indicated in the standard, given that what we are interested in knowing is the noise produced in the corridor towards the room.
- Vertical partition containing the indicator: the bathroom is taken as the transmitting enclosure and Enclosure 2 as the receiving enclosure, the transmission procedure being from the enclosure with the highest volume to the one with the lowest volume, as specified in the standard. In this case, it is also important to know how much of the noise produced in the bathroom reaches the control enclosure.

The results of the acoustic conditioning and acoustic insulation tests carried out in the initial state are presented in the following sections.

2.1 Acoustic conditioning

Typical acoustic quality paremeters have been measured in each room. Despite most of these parameters are usually evaluated with occupied room conditions, they have been used as an estimation of the rooms behaviour. The obtained results in unocuppied room conditions are presented in Table 1.

Table 1 – Measured parameters of the enclosures under study

Acoustical Parameter	Control room (unoccupied)	Studio Room (unoccupied)	Target value (occupied)
RTmid, (500 Hz - 1 KHz)	0,96 s.	0,90 s.	0,2 ≤ RTmid ≤ 0,4 s.
C50, (500Hz - 4kHz)	4,5 dB	3,8 dB	> 2 dB
Definition, D, (125 Hz - 4 kHz)	0,3	0,3	D > 0,5
STI	0,73	0,72	STI ≥ 0,60
Brilliance, Br, (125 Hz - 1kHz)	1,17	1,32	Br ≥ 0,89

As it can be seen in Table 1, the results obtained for most of the parameters show that not all the target values are met. The average reverberation time (RTmid) is very high value with respect to the recommended value and the definition (D) should be improved. Although the STI exceeds the defined objective, it is better if it is closer to 1 in the studio room, as it is a dedicated speech room.
Regarding the reverberation time, it is important to study it in all frequency octave bands, in order to have a better knowledge of the behaviour of the room depending on the frequency, this analysis can be seen in Figure 4.

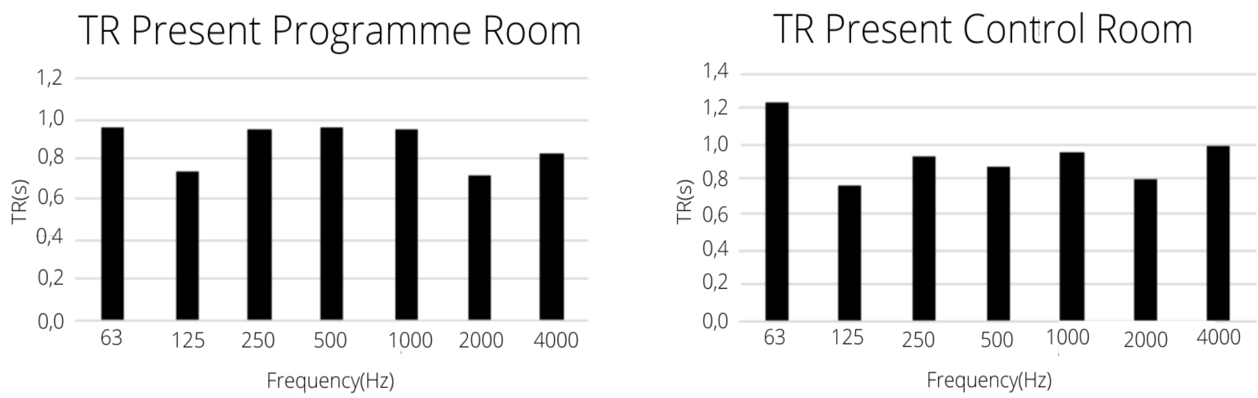

Figure 4 – Reverberation time of the Programme (left) and Control (right) rooms

It can clearly be seen that at low frequencies the reverberation time is very high, therefore, the solution to be investigated has to have a very high absorption coefficient at low frequencies or bass traps for both enclosures. In mid and high frequencies, the TR is also too high, especially in the Studio room.
In conclusion, we have two speech enclosures which are not suitable for their purpose. Their major shortcoming is especially the reverberation time. For this reason, a solution has to be found with materials with a very high absorption coefficient.

2.2 Acoustic insulation

According to the standard, five measurements are made for each source position for each of the enclosures functioning as transmitter or receiver. In addition, the background noise and reverberation time in the receiving room are analysed. A total of 38 measurements will be taken for each pair of rooms.
Table 2 shows the normalised DnT values for each studied partition. It can be seen that the acoustic insulation results are very unfavourable as no partition reach 40 dB of airbone sound insulation global level.

Table 2 – Standardised values for airborne sound insulation level

	Vertical partition Visor-S	**Vertical partition Stairs-S**	**Vertical partition Toilets-S**
DnT,A (dBA)	30,1	35,9	35,6
DnT,w (dB)	29,7	36,3	36,0

Figure 5 represents the DnT values per frequency for a detailed visualization. It can be seen how at high frequencies in the vertical partition Stairs (red) and Toilets (blue) reach values close to and above 40 dB, except in the vertical partition Viewer (blue), as a consequence of the viewer containing this wall.
On the other hand, at low and medium frequencies, the three partitions have poor DnT values.

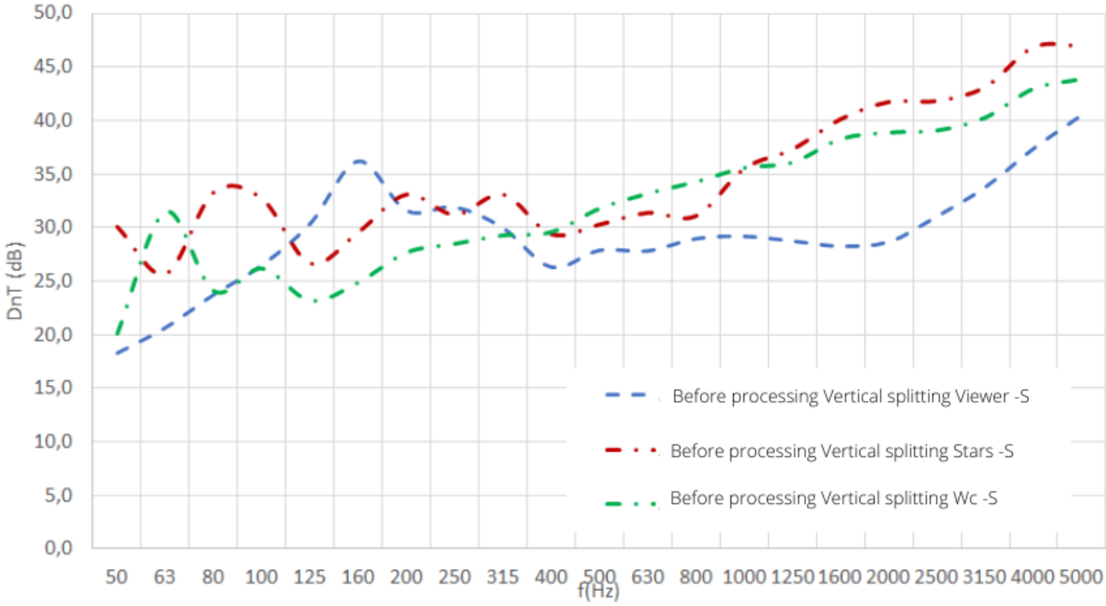

Figure 5 – DnT (dB) of the measured vertical partitions

In summary, there is a poor level of sound insulation that allows external noise pollution, as in both rooms there is a surface that faces the façade of the building, in addition to the noise from the machines on the roof. The partition studied in Enclosure 1 overlooks a common area where a large number of people pass through, which is a nuisance for the use of the room. The partition between Enclosure 1 and Enclosure 2, there is noise pollution due to the fact that the wall contains a visor, and this type of gap always breaks with the insulation. And finally, the third partition that separates the toilets from the control room, it is important that it be well insulated as the noise from the toilet cisterns or people should not affect the control room.
Consequently, action will be taken to improve the sound insulation of the vertical surface separating the Studio room and the stairs, and also the vertical surface between the toilets and the control room.

3 Proposal for action

Once the enclosures have been analysed, we proceed to define a proposal for action to address the acoustic deficiencies in terms of both insulation and conditioning of these rooms.

3.1 Materials

The solution designed for this project is based on solving two problems: sound insulation and acoustic conditioning. For this reason, it is essential that the proposal be both acoustically insulating and absorbent at the same time, so that the reverberation time can be lowered and good conditioning can be achieved.
With these premises in mind, the best solution found was the structure shown in Figure 6, which consists of a wall lining system formed by a main sheet (the vertical surface to be improved), a multilayer textile felt composed of two symmetrical layers in density and thickness adhered to a high-density viscoelastic sheet and, finally, a perforated platerboard.

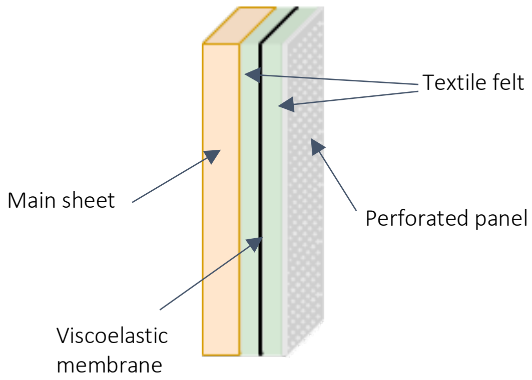

Figure 6 – Overview of the proposed solution

Different perforated panels have been used according to the needs of each vertical surface. Figure 7 shows the different panels that have been used for each wall.

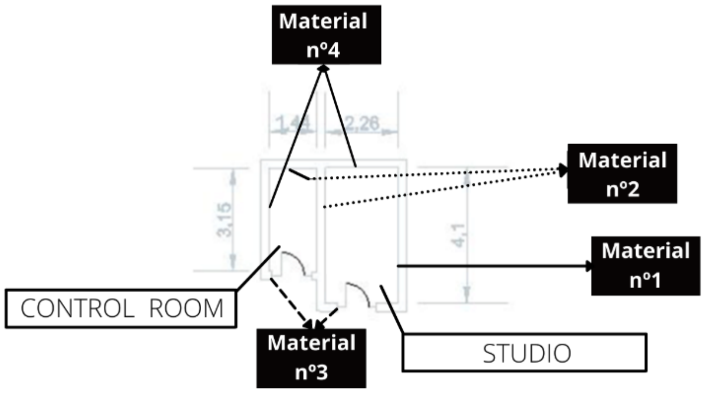

Figure 7 – Distribution of the different perforated plasterboards over the rooms

The number corresponding to each perforated plasterboard, the description of the its main characteristics and the surface area covered with each one is detailed in Table 3. Using different materials, the acoustic behaviour of each room can be tuned depending on the needs.

Table 3 – Technical characteristics of the different perforated panels

Nº Material	**Code**	**Description**	**Perf. rate (%)**	**Perf. size (mm)**	**Area (m^2)**
1	PRF1	Plasterboard with rectilinearly distributed round perforation.	16	12x12	11,5
2	PRF2	Plasterboard with perforations of different dimensions.	10	8, 15, 20	12,89
3	PRF3	Plasterboard with perforations distributed in square and non-perforated areas.	8,7	6	6,46
4	PRF4	Plasterboard with round perforations distributed in a rectilinear pattern.	18,1	12	15,63

The estimation of the sound reduction index improvement of additional layers improvement (ΔR_A) of each configuration with the different perforated plasterboards is presented in Table 4. These are theoretical values, to be used as a reference when checking the insulation solution once installed. The PB* calculation is made using a calculator provided by CHOVA, to find the insulation prediction with the evaluated products.

Table 4 – Estimation of the sound reduction index improvement of additional layers with adjustments in the elements of the multilayer composite

	ΔR_A (dB)					
HP (kg/m²)	**PB**	**PRF1 (16%)**	**PRF2 (10%)**	**PRF3 (8,7%)**	**PRF4 (18,7 %)**	**PB***
70	14	3	8	8	6	7
100	13	2	7	7	5	6
140	12	1	6	6	4	5
160	11		5	5	3	4
180	10		4	4	2	3
200	9		3	3	1	2
250	7		1	1		0

Figure 8 shows the ISO 354 standard [5] test results for each tested configuration, as detailed in the study "Materials for simultaneous acoustic insulation and conditioning", presented in the Euronoise 2021 congress [6]. From 315 Hz onwards, all the configurations present high absorption coefficient values, suitable for the problem at hand, since the reverberation time is to be reduced from 0.9s to at least 0.4s.

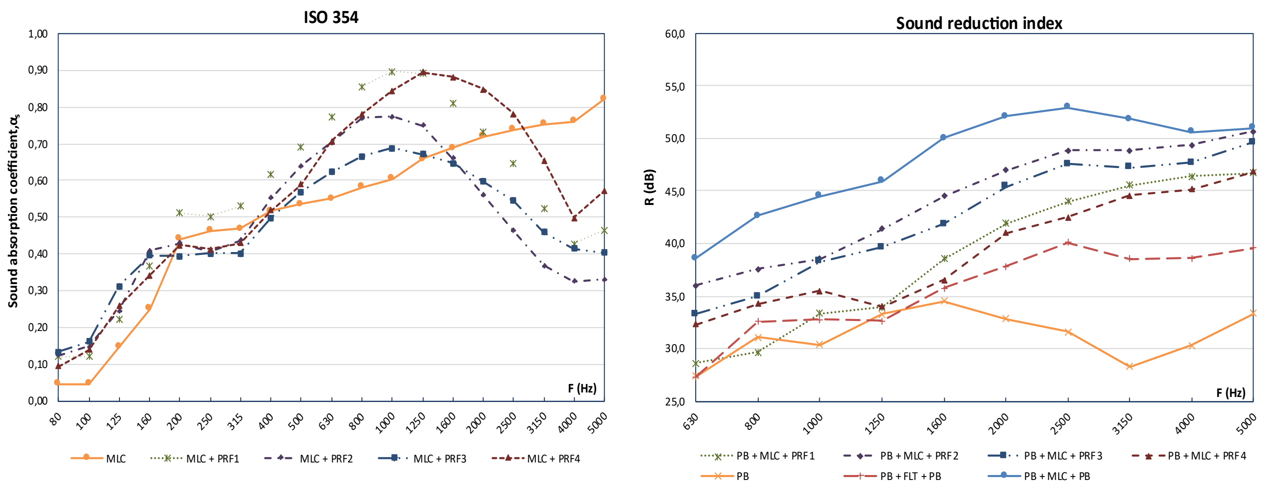

Figure 8 – ISO 354 (left) and Sound Reduction Index (right) of the assessed configurations

On the right graph of Figure 8, the results of the Sound Reduction Index, R (dB), applying the ISO 10140-2 standard [7] are presented. It can be seen, that all four plasterboard configurations are suitable to address the deficiencies of the rooms. For example, the PB+MLC+PRF4 configuration is the most suitable to be placed in the vertical partition connecting the toilet and the control room, since it is a small surface and it is more difficult to improve the insulation, as well as having a high absorption coefficient. In the case of the wall between the stairs and the studio room, the PB+MLC+PRF1 configuration has been used, as it is a larger surface area, which will provide a greater improvement in insulation, and on the other hand, the absorption coefficient is adequate.

When choosing the material, a prediction was made for the two acoustic problems: acoustic conditioning and acoustic insulation. The results for the reverberation time are presented in Figure 9.

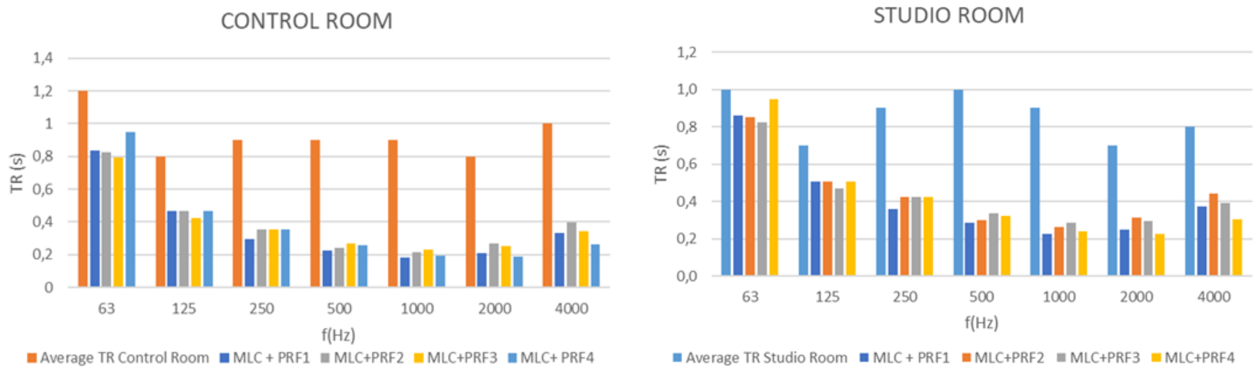

Figure 9 – Estimated reverberation time for Control Room (left) and Studio Room (right)

To validate the proposed solution, the same in situ measurements were made as in the assessment of the initial condition of the enclosures, but this time with the wall lining system installed. The results obtained before and after the acoustic treatment are presented in Table 5.

Table 5 – Comparative table of results of the acoustic parameters of the rooms

After acoustic treatment			
Acoustical Parameter	**Studio room (unoccupied)**	**Control room (unoccupied)**	**Target value (occupied)**
RTmid (500 Hz - 1 KHz)	0,25	0,20	0,2 ≤ RTmid ≤ 0,4 s.
Brilliance (Br)	1,33	1,32	Br ≥ 0,89
STI	0,91	0,91	STI ≥ 0.60
C50, (500Hz - 4kHz)	15,21	19,5	C50 > 2 dB
Definition, D, (125 Hz - 4 kHz)	0,97	0,99	D > 0.5
Before acoustic treatment			
Acoustical Parameter	**Studio room (unoccupied)**	**Control room (unoccupied)**	**Target value (occupied)**
RTmid (500 Hz - 1 KHz)	0,90	0,96	0,2 ≤ RTmid ≤ 0,4 s.
Brilliance (Br)	1,03	1,17	Br ≥ 0,89
STI	0,72	0,73	STI ≥ 0.60
C50, (500Hz - 4kHz)	3,80	4,5	C50 > 2 dB
Definition, D, (125 Hz - 4 kHz)	0,30	0,30	D > 0.5

The average reverberation time (RTmid) has clearly decreased compared to the initial state, this is due to the highly absorbent textile felt of the multilayer composite material. The intelligibility of the rooms has also improved considerably, reaching a value very close to 1.

3.2 Sound insulation

With regard to sound insulation, the wall lining system was applied only to two of the three measured vertical partitions: the vertical partition Stairs-Studio Room and the vertical partition Toilets-Control Room. Analysing the graph presented in Figure 10, which corresponds to the veritcal partition Stairs-Studio Room, it can be affirmed in almost all frequency bands, especially in the medium and high frequencies, the proposed solution improves the acoustic insulation and also, as verified in the previous section, the acoustic conditioning of the room.

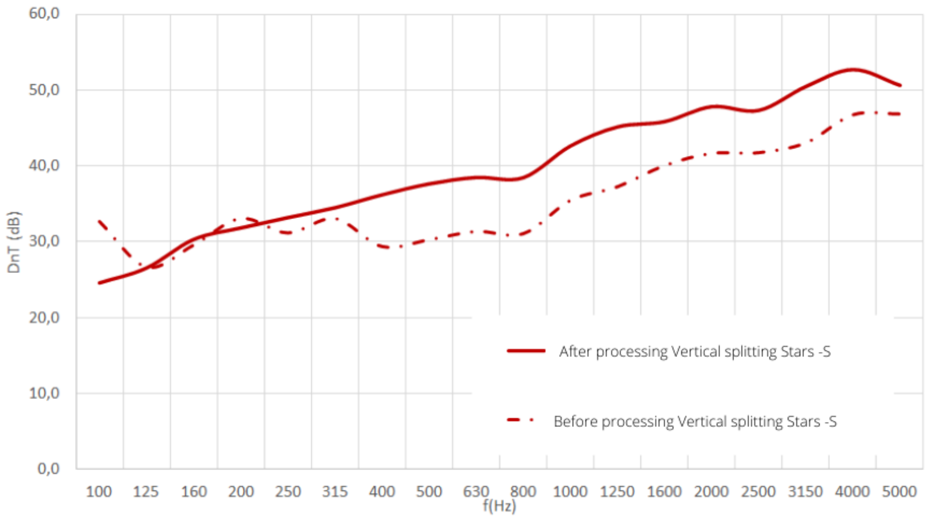

Figure 10 – Insulation of the vertical partition Stairs-Studio Room

Table 6 presents the overall values of the standardised weighted level difference DnT,w (dB) before and after the acoustic treatment, showing a 6 dB improvement in insulation.

Table 6 – DnT values for the vertical partition Stairs-Studio Room

	Before treatment	**After treatment**	**Improvement**
DnT,A (dBA)	35,9	41,4	5,5
DnT,w (dB)	36,3	42,3	6,0

Some images of the Studio Room after installing the proposed solution can be seen in Figure 11.

Figure 11 – Images of the Studio Room with the proposed solution installed

In Figure 12, the graph corresponding to the vertical partition Toilets-Control Room is presented. It can be seen that the proposed solution improves the acoustic insulation in almost every frequency band.

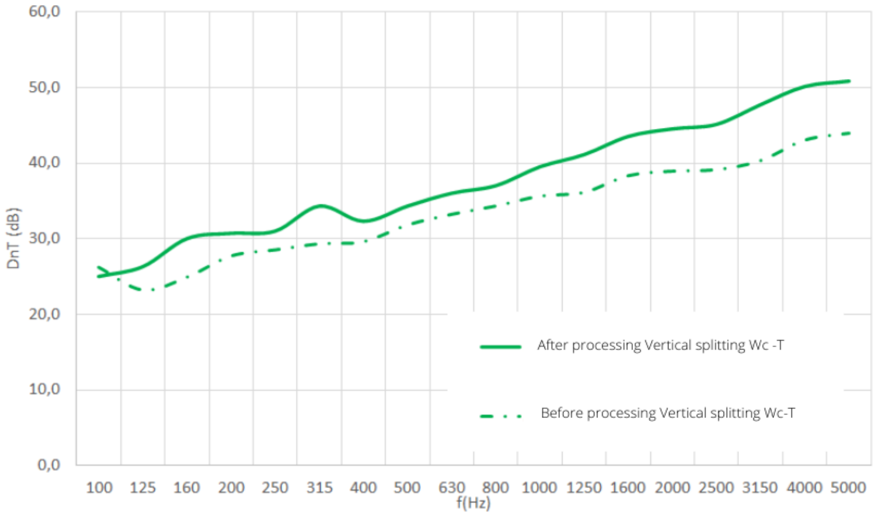

Figure 12 – Insulation of the vertical partition Toilets-Control Room

In this case, the insulation improvement is lower than in the previous one, as there is less surface area to be applied. As presented in Table 7, there is an improvement of almost 4 dB of improvement after applying the acoustic treatment.

Table 7 – Insulation of the vertical partition Toilets-Control Room

	Before treatment	**After treatment**	**Improvement**
DnT,A (dBA)	35,6	39,3	3,7
DnT,w (dB)	36,0	39,8	3,8

Some images of the Studio Room after installing the proposed solution can be seen in Figure 13.

Figure 13 – Control room with the proposed solution installed

4 Conclusions

Two very small rooms with very unfavourable conditions in terms of both acoustic conditioning and insulation have been acoustically treated in order to function as a radio studio. The poor initial acoustic conditions have been revealed in the analysis of the initial in situ measurements. Subsequently, a solution has been studied with two objectives, to improve the acoustical conditioning and insulation of the rooms, so that they can finally be used as radio studio. For this purpose, a solution was designed by means of a wall lining system formed by a main sheet (the vertical surface to be improved), a multilayer textile felt composed of two symmetrical layers in density and thickness adhered to a high-density viscoelastic sheet and, finally, different perforated platerboards, thus adjusting the acoustic parameters (TR, C50 and STI) and improving the acoustic insulation (between 4 and 6 dB improvement). This study shows that two acoustic problems can be solved with the same solution.

Acknowledgements

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