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ACOUSTIC INSULATION IN PLASTERBOARD SYSTEMS WITH MINERAL WOOL

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ABSTRACT

One of the most important features in plasterboard systems with mineral wool (MW) is the acoustic insulation they provide between different rooms, with minimal space and weight requirements.

When designing this type of system, there are several factors that can influence the acoustic insulation: the number and type of boards, the spacing between the profiles, the bracing of the structure, the thickness of the system... But are they all equally important? What is the influence of the density of mineral wool in this type of system?

The paper analyses the acoustic behavior of plasterboard systems with mineral wool, and the influence of system parameters on acoustic insulation, in order to help designers to configure systems to reduce the noise between neighbors through acoustic retrofitting in residential buildings.

Keywords: *plasterboard, mineral wool, acoustic insulation,*

1. INTRODUCTION

Acoustic insulation is nowadays one of the most important features in today's building systems. Acoustic independence between rooms is one of the main requirements of internal partitions in order to guarantee the well-being of all users.

2. LIGHT VS HEAVY CONSTRUCTION

It is important to distinguish between massive and light construction systems. First ones mentioned consist of a massive structure of walls, and second ones mentioned consist of a structure of pillars and beams, including light façade systems, wood and glass structures, etc.

Massive systems work with the mass of the element. The thicker the construction element, the better acoustic insulation. However, the stiffness of the material implies a variation in the critical frequency.

Nevertheless, in lightweight systems, particularly in gypsum plasterboard (GP) partition systems, consisting of a plasterboard layer, followed by a cavity and closed again by another plasterboard layer, it is the width of the cavity that has the greater impact on the increase in acoustic insulation, as well as the mass of the plasterboard layers.

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3. OPERATION OF LIGHT WEIGHT SYSTEMS

This performance is due to the fact that these systems operate as a mass-spring-mass system. The graph shows three different zones (Figure 1):

- **First zone**: The two "masses" oscillate in phase, and behave as a single-layer system.
- **Second zone**: The "masses" oscillate at the highest amplitude, where the resonance frequency is perceived.
- **Third zone**: The two "masses" oscillate independently, where the isolation is greater than in a single-layer wall.

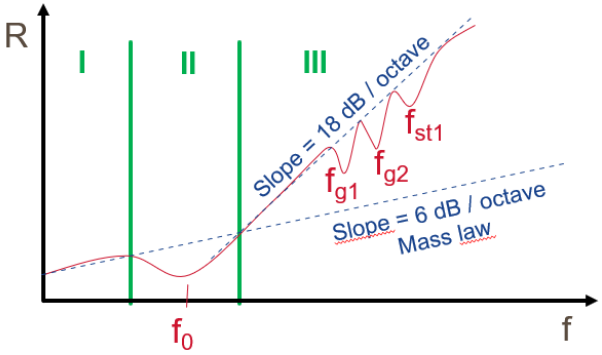


Figure 1. Operation of plasterboard systems

4. PARAMETERS INFLUENCING THE PLASTERBOARD SYSTEMS

It is also possible to optimize the acoustic performance of these systems by adding or modifying elements of their composition.

There are several parameters that influence the acoustic insulation performance of a plasterboard system:

- Insulation in the cavity and the thickness of the insulation, usually mineral wool (MW).
- Cavity width.
- Number of plasterboards.
- Distance between profiles.
- Type of profiles.
- Bracing of the structures.
- Total thickness of the system.
- Installation conditions.

However, there are aspects that are sometimes considered to be influential but are not, such as the density of the mineral wool.

5. CAVITY INSULATION AND MINERAL WOOL THICKNESS

Based on tests on the same system, 2 Placo® BA15 + M150 + 2 Placo® BA15 with 600 mm modulation between profiles, an increase in acoustic insulation can be perceived (Figure 2) by increasing the thickness of the mineral wool in the cavity:

- 0 mm MW: 47 dBA. (Figure 3)
- 65 mm MW: 52 dBA. (Figure 4)
- 150 mm MW: 53 dBA. (Figure 5)

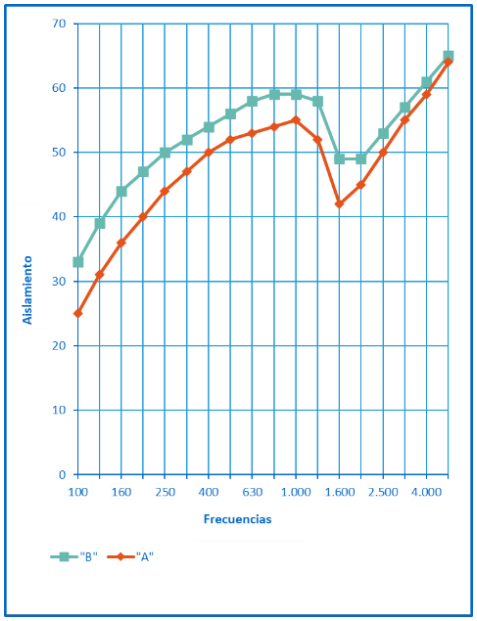


Figure 2. Comparison between systems:

2 Placo® BA15 + M150 (MW 0 mm) + 2 Placo® BA15 with 600 mm modulation (sample A)
2 Placo® BA15 + M150 (MW 150 mm) + 2 Placo® BA15 with 600 mm modulation (sample B)

frec. (Hz(	R(dB)	R(dB)
50	12	
63	8	11
80	17	
100	25	
125	31	28
160	36	
200	40	
250	44	43
315	47	
400	50	
500	52	52
630	53	
800	54	
1000	55	54
1250	52	
1600	42	
2000	45	45
2500	50	
3150	55	
4000	59	58
5000	64	

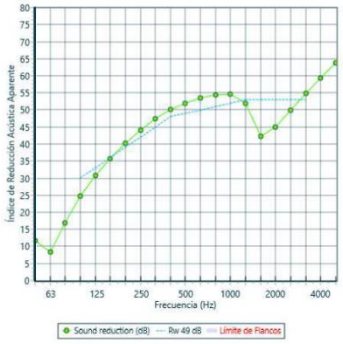


Figure 3. Simulation results from system 2 Placo® BA15 + M150 (MW 0 mm) + 2 Placo® BA15

frec. (Hz(	R(dB)	R(dB)
50	11	
63	14	14
80	23	
100	31	
125	37	34
160	42	
200	46	
250	49	48
315	52	
400	54	
500	56	56
630	58	
800	59	
1000	59	59
1250	58	
1600	49	
2000	49	50
2500	53	
3150	57	
4000	61	60
5000	65	

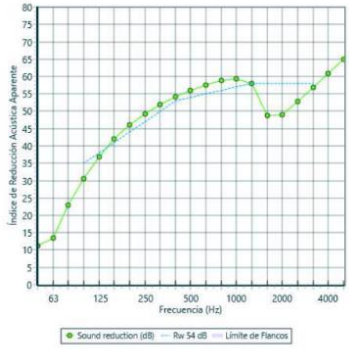


Figure 4. Simulation results from system 2 Placo® BA15 + M150 (MW 65 mm) + 2 Placo® BA15

frec. (Hz(	R(dB)	R(dB)
50	12	
63	15	15
80	24	
100	33	
125	39	36
160	44	
200	47	
250	50	50
315	52	
400	54	
500	56	56
630	58	
800	59	
1000	59	59
1250	58	
1600	49	
2000	49	50
2500	53	
3150	57	
4000	61	60
5000	65	

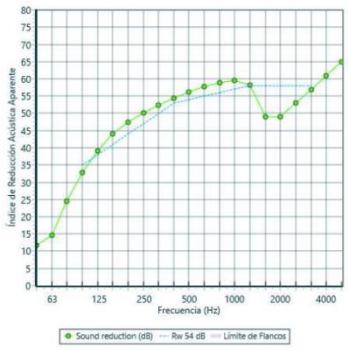


Figure 5. Simulation results from system 2 Placo® BA15 + M150 (MW 150 mm) + 2 Placo® BA15

Furthermore, it is observed that the inclusion of insulation in the plasterboard system cavity, with an air flow resistance of at least 5 kPa·s/m^2, achieves optimization of this system, as the resonance frequency is outside the range of interest for these systems, as well as reducing the loss of coincidence frequency in the overall computation of the system.

6. CAVITY WIDTH

Enlarging the cavity allows the thickness of the internal MW to be increased, giving the following results (Figure 6):

- M48 (MW): 47 dBA. (Figure 7)
- M70 (MW): 50 dBA. (Figure 8)
- M100 (MW): 52 dBA. (Figure 9)

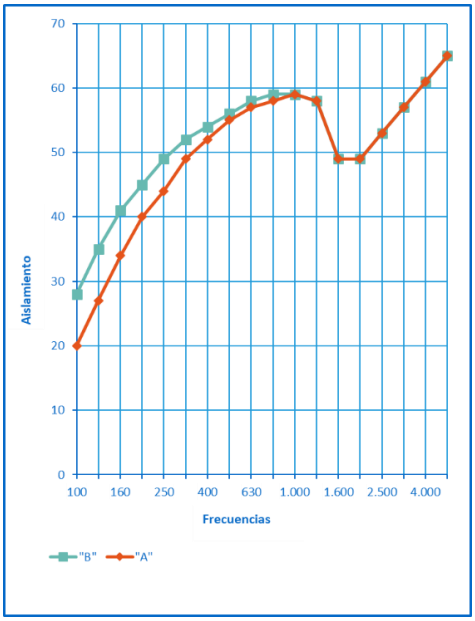


Figure 6. Comparison between systems:

2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 600 mm modulation (sample A)
2 Placo® BA15 + M100 (MW) + 2 Placo® BA15 with 600 mm modulation (sample B)

Figure 7. Simulation results from system 2 Placo® BA15 + M48 (MW) + 2 Placo® BA15

frec. (Hz(	R(dB)	R(dB)
50	20	
63	14	16
80	16	
100	24	
125	31	28
160	38	
200	43	
250	47	46
315	50	
400	53	
500	55	55
630	57	
800	59	
1000	59	59
1250	58	
1600	49	
2000	49	50
2500	53	
3150	57	
4000	61	60
5000	65	

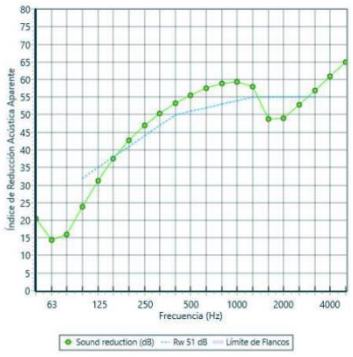


Figure 8. Simulation results from system 2 Placo® BA15 + M70 (MW) + 2 Placo® BA15

frec. (Hz(	R(dB)	R(dB)
50	15	
63	13	15
80	19	
100	28	
125	35	32
160	41	
200	45	
250	49	48
315	52	
400	54	
500	56	56
630	58	
800	59	
1000	59	59
1250	58	
1600	49	
2000	49	50
2500	53	
3150	57	
4000	61	60
5000	65	

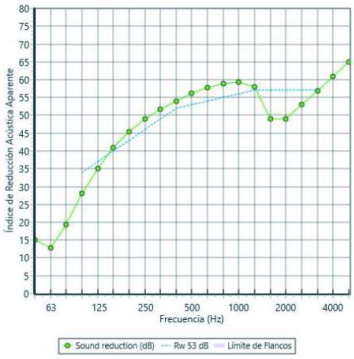
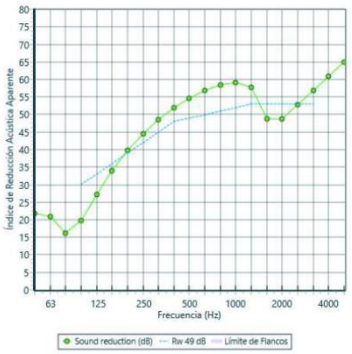


Figure 9. Simulation results from system 2 Placo® BA15 + M100 (MW) + 2 Placo® BA15

For conventional systems up to about 100 mm cavity thickness, the insulation effect is approximately a 1 dB increase for every 1 cm of mineral wool included (although it can be seen that this is not linear).

frec. (Hz(	R(dB)	R(dB)
50	22	
63	21	19
80	16	
100	20	
125	27	24
160	34	
200	40	
250	44	43
315	49	
400	52	
500	55	54
630	57	
800	58	
1000	59	58
1250	58	
1600	49	
2000	49	50
2500	53	
3150	57	
4000	61	60
5000	65	



7. MINERAL WOOL DENSITY

One characteristic of mineral wool that is often confusing is the influence of mineral wool density on plasterboard systems.

The Spanish standard UNE-EN 13162:2012+A1:2015 “Thermal insulation products for building applications” does not consider density as a performance characteristic for products manufactured under these conditions.

8. NUMBER OF PLASTERBOARDS

In self-supporting plasterboard framing systems, an increase in the surface mass of the mass-spring-mass system implies an improvement in the acoustic insulation performance. Therefore, increasing the number of boards will provide better acoustic insulation results. (Figure 10) (Figure 11) (Figure 7).

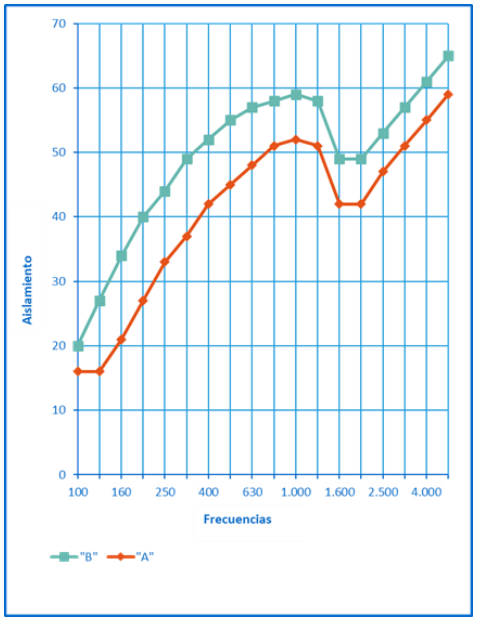


Figure 10. Comparison between systems:

Placo® BA15 + M48 (MW) + Placo® BA15 with 600 mm modulation (sample A)
2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 600 mm modulation (sample B)

frec. (Hz(	R(dB)	R(dB)
50	18	
63	18	18
80	18	
100	16	
125	16	17
160	21	
200	27	
250	33	31
315	37	
400	42	
500	45	44
630	48	
800	51	
1000	52	51
1250	51	
1600	42	
2000	42	43
2500	47	
3150	51	
4000	55	54
5000	59	

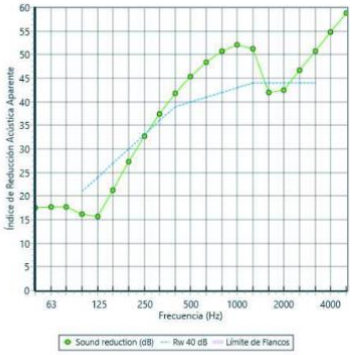


Figure 11. Simulation results from Placo® system BA15 + M48 (MW) + Placo® BA15 (38 dBA)

The increase in boards mass increases the overall acoustic insulation value by approximately 9 dBA in a plasterboard partition system by adding one layer of plasterboard on each side of the system.

9. TYPE OF PLASTERBOARDS

There are boards with improved acoustic performance. In the case of Saint-Gobain, changing from a plasterboard Placo® BA to a plasterboard Placo® PPH allows greater acoustic insulation to be obtained, specifically of 3 dBA in the solution tested (Figure 12) (Figure 13) (Figure 14).

Therefore, there may be situations in the project where this change could be an important aspect.

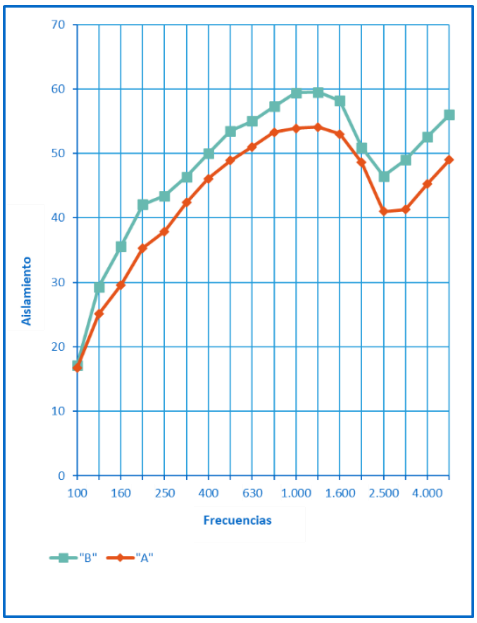
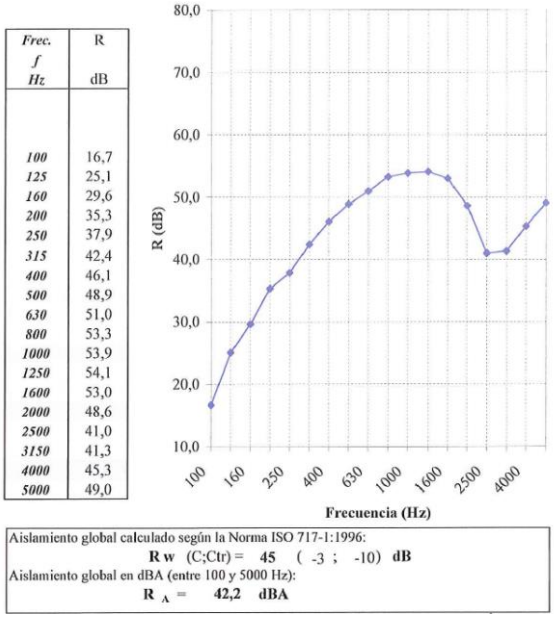


Figure 12. Comparison between systems:

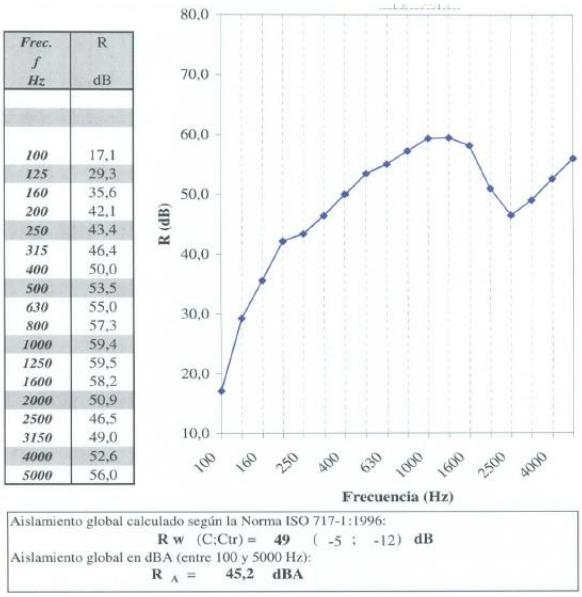
Placo® BA15 + M48 (MW) + Placo® BA15 with 600 mm modulation (sample A)
Placo® PPH15 + M48 (MW) + Placo® PPH15 with 600 mm modulation (sample B)



Frec. f Hz	R dB
100	16,7
125	25,1
160	29,6
200	35,3
250	37,9
315	42,4
400	46,1
500	48,9
630	51,0
800	53,3
1000	53,9
1250	54,1
1600	53,0
2000	48,6
2500	41,0
3150	41,3
4000	45,3
5000	49,0

Aislamiento global calculado según la Norma ISO 717-1:1996:
R w (C;Ctr) = 45 (-3 ; -10) dB
Aislamiento global en dBA (entre 100 y 5000 Hz):
R_A = 42,2 dBA

Figure 13. Test results from Placo® system BA15 + M48 (MW) + Placo® BA15 (CTA 116/07/AER-1)



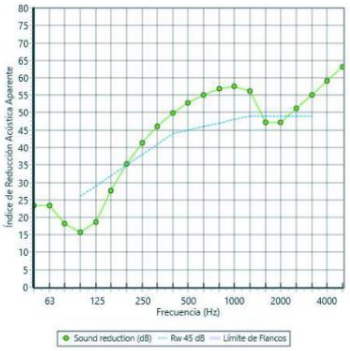
Frec. f Hz	R dB
100	17,1
125	29,3
160	35,6
200	42,1
250	43,4
315	46,4
400	50,0
500	53,5
630	55,0
800	57,3
1000	59,4
1250	59,5
1600	58,2
2000	50,9
2500	46,5
3150	49,0
4000	52,6
5000	56,0

Aislamiento global calculado según la Norma ISO 717-1:1996:
R w (C;Ctr) = 49 (-5 ; -12) dB
Aislamiento global en dBA (entre 100 y 5000 Hz):
R_A = 45,2 dBA

Figure 14. Test results from Placo® system PPH15 + M48 (MW) + Placo® PPH15 (CTA 213/09/AER)

The Placo® BA15 has a density of 653 kg/m^3, while the Placo® PPH15 has a density of 966 kg/m^3. The increase in the plasterboard density also means an improvement in acoustic insulation, so the type of board used can improve the results.

frec. (Hz(	R(dB)	R(dB)
50	23	
63	23	21
80	18	
100	16	
125	19	19
160	28	
200	35	
250	41	39
315	46	
400	50	
500	53	52
630	55	
800	57	
1000	57	57
1250	56	
1600	47	
2000	47	48
2500	51	
3150	55	
4000	59	58
5000	63	



10. PROFILE SPACING

A profile spacing of less than 500 mm can reduce the acoustic insulation of the system by 4-5 dB. In Spain, due to the dimensions of the GP, the profile spacing is set at 400 mm and 600 mm, and a decrease in acoustic insulation is observed in structures with modulation every 400 mm (Figure 15) (Figure 16) (Figure 7).

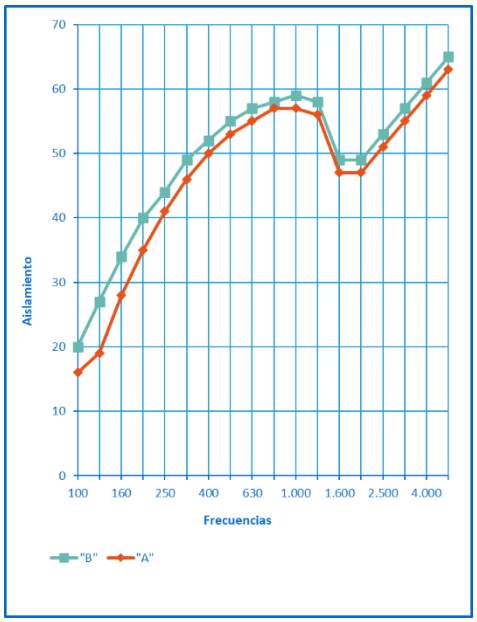


Figure 15. Comparison between systems:

2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 400 mm modulation (sample A)

2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 600 mm modulation (sample B)

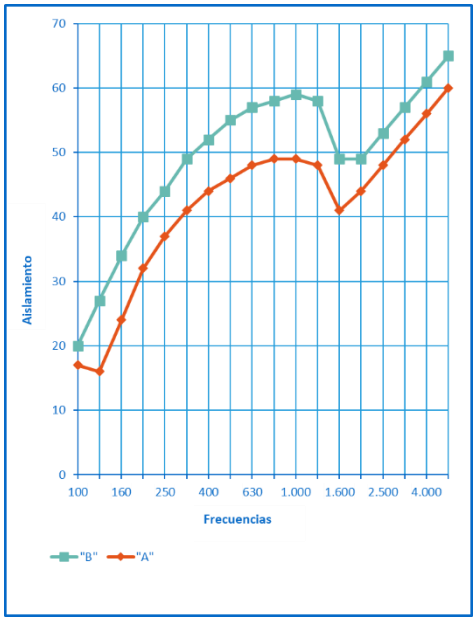


Figure 16. Simulation results from system 2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 400 mm modulation (42 dBA)

Approximation between profiles provides more stable systems that achieve greater mechanical heights, but the system is stiffer, reducing the acoustic performance by approximately 5 dBA.

11. TYPE OF PROFILES

If we compare two systems that change the composition of their profiles, one based on the metal profiles of the plasterboard partition and wall systems, and the other based on wooden profiles, we obtain the following results (Figure 17) (Figure 18) (Figure 7):

Figure 17. Comparison between systems:

2 Placo® BA15 + 48 mm wooden profile (MW) + 2 Placo® BA15 with 600 mm modulation (sample A)
2 Placo® BA15 + M48 (MW) + 2 Placo® BA15 with 600 mm modulation (sample B)

frec. (Hz(	R(dB)	R(dB)
50	23	
63	24	22
80	19	
100	17	
125	16	18
160	24	
200	32	
250	37	35
315	41	
400	44	
500	46	45
630	48	
800	49	
1000	49	49
1250	48	
1600	41	
2000	44	43
2500	48	
3150	52	
4000	56	55
5000	60	

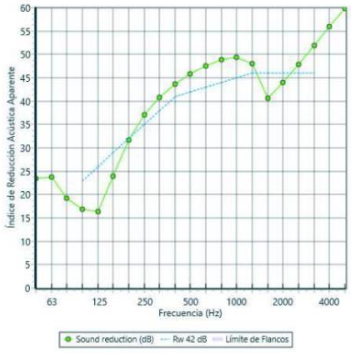


Figure 18. Simulation results from system 2 Placo® BA15 + 48 mm wooden structure (MW) + 2 Placo® BA15 with 400 mm modulation (40 dBA)

The metal profiles of plasterboard systems provide better acoustic insulation than wooden profiles, giving an improvement of up to 8 dBA. It also moves the resonance

frequency to a lower frequency, out of the range of interest.

12. BRACING OF STRUCTURES

In double-structured systems, the use of unbraced structures can lead to a significant improvement in acoustic insulation (Figure 19) (Figure 20) (Figure 21).

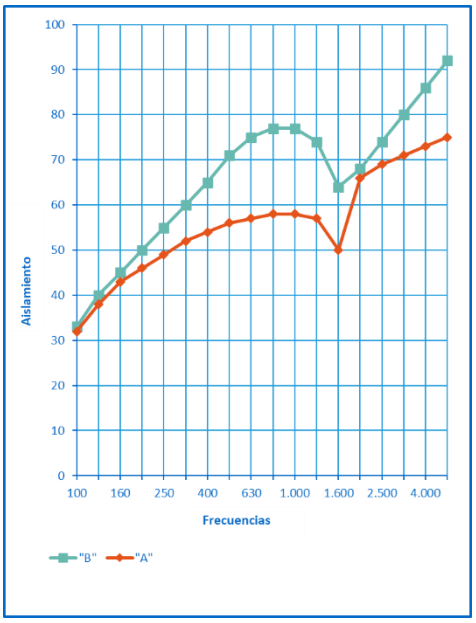


Figure 19. Comparison between systems:

2 Placo® BA15 + M48 (MW) + M48 (MW) + 2 Placo® BA15 with braced structures (sample A)
2 Placo® BA15 + M48 (MW) + M48 (MW) + 2 Placo® BA15 with non-braced structures (sample B)

frec. (Hz(	R(dB)	R(dB)
50	18	
63	16	18
80	24	
100	32	
125	38	35
160	43	
200	46	
250	49	49
315	52	
400	54	
500	56	55
630	57	
800	58	
1000	58	58
1250	57	
1600	50	
2000	66	55
2500	69	
3150	71	
4000	73	72
5000	75	

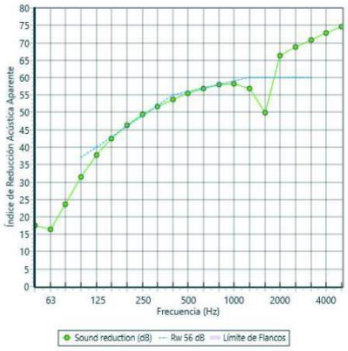


Figure 20. Simulation results from system 2 Placo® BA15 + M48 (MW) + M48 (MW) + 2 Placo® BA15 with braced structures (55 dBA)

frec. (Hz(	R(dB)	R(dB)
50	15	
63	19	18
80	26	
100	33	
125	40	37
160	45	
200	50	
250	55	54
315	60	
400	65	
500	71	68
630	75	
800	77	
1000	77	76
1250	74	
1600	64	
2000	68	67
2500	74	
3150	80	
4000	86	83
5000	92	

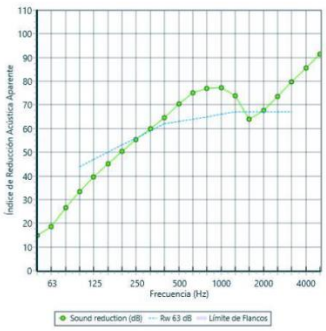


Figure 21. Simulation results from system 2 Placo® BA15 + M48 (MW) + M48 (MW) + 2 Placo® BA15 with non-braced structures (60 dBA)

Bracing between structures provides systems that reach a higher mechanical height, but as in the previous point, the system is stiffened, reducing the acoustic performance. The acoustic insulation can be reduced by approximately 5 dBA.

13. TOTAL THICKNESS OF THE SYSTEM

On the basis of each of the characteristics studied, it can be seen that increasing the overall thickness of the system brings with it a number of aspects that generally improve the acoustic performance of the system:

- Cavity width and thickness of MW in the cavity: It is observed that in systems with cavity widths up to 100 mm, there is an increase of 1 dB for every 1 cm of MW included. In addition, the inclusion of MW in the cavity means that the

resonance frequency is outside the range of interest for these systems, as well as the coincidence frequency for both layers. The difference between including or not including MW in the cavity can make a difference of about 8 dB.

- Number of boards: Increasing the plasterboard mass increases the overall sound insulation value of a plasterboard partition system by approximately 9 dBA by adding one layer of board on each side of the system.

14. INSTALLATION

Finally, it is important to mention that the quality of the construction will have a great influence on the effectiveness of the acoustic insulation of the solution, with differences ranging from 2 to 15 dB.

Acoustic bridges must be taken into account, and it is recommended that an elastic band be installed in the junction of the profiles with the support structure, as well as at the junction between the systems, in order to avoid the transmission of noise between rooms.

15. CONCLUSION

As a manufacturer of plasterboard systems, we can specify the following points based on the acoustic requirements of the project:

- Fill the air cavity of the systems with mineral wool.
- Increase the number of boards to achieve better acoustic performance.
- Use the appropriate board for improved acoustic performance.
- Use double non-braced systems for partition walls between apartments, hotel rooms, etc.
- Pay attention to the performance characteristics of each product and the complete system in each case.

16. REFERENCES

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