LGAI

LGAI Technological Center, S.A.
Campus de la UAB
Apartado de Correos 18
E - 08193 Bellaterra (Barcelona)
T +34 93 567 20 00
F +34 93 567 20 01
www.appluscorp.com

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ilac-MRA ENAC ENSAYOS Nº 9/LE766

Bellaterra: 26th May, 2009

Expedient number: 09/32302041

Petitioner's reference: **RECTICEL IBÉRICA, S.L.**
C/ Catalunya, nº 13, Pol. Ind. Can Oller
08130 Sta. Perpetua de Mogoda (Barcelona)

TEST REPORT

This test report is the translation of the original Spanish version expedient number 09/32301479

REQUESTED TEST: Measurement of the airborne sound insulation in conformity with the standard UNE-EN ISO 140-3:1995 of a vertical partition composed by a basic ceramic brick wall coated with Recfoam© U80 panel 40 mm-thick and gypsum plasterboard.

DATE TEST PERFORMED: 1st April, 2009

LGAI Technological Center, S.A.

Xavier Costa Guallar
Manager of Acoustics
LGAI Technological Center S.A.

LGAI Technological Center, S.A.

Xavier Roviralta Roca
Technical Assistant
LGAI Technological Center S.A.

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This document consists of 18 pages of wich 0 are annexes.

1.- OBJECT OF MEASUREMENT

Measurement of the airborne sound insulation in conformity with the standard UNE-EN ISO 140-3:1995 of a vertical partition composed by a basic ceramic brick wall coated with Recfoam© U80 panel 40 mm-thick and 80 Kg/m^3, and 18mm-thick gypsum plasterboard.

2.- TEST EQUIPMENT

The equipment used in test is the following:

- Spectrum analyser number id: 103099 (Bruel&Kjaer mod. Pulse)
- Microphone calibrator number id: 103132 (Bruel&Kjaer mod. 4231)
- Diffuse field microphones number id: 103118, 103122, 103123, 103126, 103128 and 103131 (Bruel&Kjaer mod. 4943)
- Sound sources number id: 103098 (AVM mod. DO12) and 103124 (CESVA mod. BP012)
- Power amplifier number id: 103111 (CESVA mod. AP600)
- Thermo-hygrometers number id: 103108 (RS mod 212-124) and 103021 (Oregon Scientific mod. BA116)
- Tape measure number id: 103095 (Stanley mod. Powerlock)

3.- TEST PROCEDURE AND EVALUATION

3.1. TEST METHOD

Test carried out in conformity with APPLUS-CTC's procedure C521 0197, based on the European standard UNE-EN ISO 140-3:1995, 'Laboratory measurement of airborne sound insulation of building elements'.

To determine the sound reduction index between two rooms with a common partition, a sound is generated in the source room. The emitted sound power should be high enough to measure, into the receiving room, a sound pressure level at least 15 dB higher than the background noise level, at any frequency band. If this is not fulfilled, corrections specified in the standard shall be applied.

After averaging the sound pressure level at different microphone positions in both rooms, the level difference, D, can be calculated as:

$$D = L_1 - L_2$$

where:

- L_1 is the average sound pressure level in the source room;
- L_2 is the average sound pressure level in the receiving room (with correction for background noise when necessary)

This level difference should be corrected by a term that depends on the reverberation time, the receiving room's volume and the common surface between both rooms. Then the sound reduction index, R, is evaluated from:

$$R = L_1 - L_2 + 10\,Log\,(\frac{S\,T}{0.163\,V})\quad \text{[dB]}$$

where:

- S is the area of the separating element.
- T is the reverberation time in the receiving room. Reverberation time is defined as the time required for the sound pressure level to decrease 60 dB after sound source is turned off.
- V is the receiving room volume.

3.2. A-WEIGHTED SOUND REDUCTION INDEX CALCULATION, R_A

The A-weighted sound reduction index of a building element is the global evaluation, in dBA, of the sound reduction index, R, for an incident pink noise normalized A-weighted. In the Annexe A of the *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*, R_A is calculated from :

$$R_A = -\,10\,Log\sum_{i=1}^{n} 10^{(L_{Ar,i} - R_i)/10}\quad \text{[dBA]}$$

where:

- R_i is the value of sound reduction index at every frequency band, in dB.
- $L_{Ar,i}$ is the value of A-weighted pink noise spectrum at every frequency band, in dBA.

freq. (Hz)	100	125	160	200	250	315
$L_{Ar,i}$	-30,1	-27,1	-24,4	-21,9	-19,6	-17,6
freq. (Hz)	400	500	630	800	1000	1250
$L_{Ar,i}$	-15,8	-14,2	-12,9	-11,8	-11,0	-10,4
freq. (Hz)	1600	2000	2500	3150	4000	5000
$L_{Ar,i}$	-10,0	-9,8	-9,7	-9,8	-10,0	-10,5

Table 3.1: $L_{Ar,I}$ values

3.3. WEIGHTED SOUND REDUCTION INDEX CALCULATION, Rw

The weighted sound reduction index, R_w, is defined as the value, in decibels, of the reference curve, at the frequency of 500 Hz, after shifting it according to the method laid down in this document (method specified in standard UNE-EN ISO 717-1).

To evaluate the results of a measurement of R (airborne sound insulation in one-third octave bands), the reference curve is shifted in steps of 1 dB towards the measured curve until the sum of the unfavourable deviations is as large as possible but no more than 32 dB. An unfavourable deviation at a particular frequency occurs when the result of measurement is less than the reference curve. Only frequencies within the range of 100 to 3150 Hz are taken into account.

frec. (Hz)	100	125	160	200	250	315
Ref.	33	36	39	42	45	48
frec. (Hz)	400	500	630	800	1000	1250
Ref.	51	52	53	54	55	56
frec. (Hz)	1600	2000	2500	3150	4000	5000
Ref.	56	56	56	56	56	56

Table 3.2: Values of the reference curve

3.4. ADAPTATION TERMS ($C_{100\text{-}5000}$; $C_{tr,100\text{-}5000}$)

As defined in standard UNE-EN ISO 717-1, the adaptation terms C and Ctr are corrections that can be added to a R_w airborne rating to take into account the features of peculiar spectrums.

The Ctr term is used because it targets the low frequency performance of a building element and in particular the performance achieved in the 100 to 315 Hz frequency range. This term was originally developed to describe how a building element would perform if subject to excessive low frequency sound sources such as traffic and railway noise.

In the next informative table, several cases are presented and which adaptation terms can be used:

Suitable Adaptation Term	Kind of sound source
C (Adaptation term for pink noise)	Human Activities (conversations, music, radio, TV) Kinder games High and medium velocity trains Motorway (> 80 Km/h) Jet aircraft, (short distances) Factory emitting medium and high frequency noise
C_{tr} (adaptation term for traffic)	Urban traffic Low speed trains Jet aircraft Music from discotheque Factory emitting low frequency noise

Table 3.3: Adaptation terms and its suitable use

3.5. SOUND REDUCTION IMPROVEMENT INDEX OF ADDITIONAL LINING, ΔR

In Annex A of the *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*, ΔR is defined as the increased global noise reduction index of a building element, by applying a treatment or adding a lining to the basic building element. It is valued in terms of the difference between the sound reduction index, R, of a reference building element with the improvement lining, and that of the reference building element per se. It is a function of frequency.

Annex E of the same *"DB-HR Protección frente al ruido"*, as well as standard UNE-EN ISO 140-16:2007 "Laboratory measurement of the sound reduction index improvement by additional lining" defines the measurement and evaluation method of said improvement.

The value of sound reduction improvement index, ΔR, will be obtained in terms of the frequency, for the third octave bands of the 100-5000 Hz interval, by means of the difference between the values pertaining to the sound reduction index of the basic building element with the lining, R_{with}, and without it, $R_{without}$ these values being measured at the laboratory, in compliance with Standard UNE-EN ISO 140-3, and expressed as follows:

$$\Delta R = R_{with} - R_{without} \quad \text{[dB]}$$

With regard to the basic building elements on which the lining or wall treatment are to be applied, the *"DB-HR Protección frente al ruido"* document and standard UNE-EN ISO 140-16 state two types of constructions, listed below.

3.5.1 BASIC WALL WITH A LOW COINCIDENCE FREQUENCY ("HEAVY BASIC WALL")

Homogeneous building element with a surface mass, *m*, of 350 ± 50 Kg/m^2, with a coincidence frequency on 125 Hz octave band. When the blocks used to build it are hollow, its density should not be lower than 1,600 Kg/m^3, and thickness resonances below 3,150 Hz are not allowed.

Freq. (Hz)	100	125	160	200	250	315
$R_{0,I}$	40	40	40	40	41	43.5
Freq. (Hz)	400	500	630	800	1000	1250
$R_{0,I}$	46.1	48.5	51	53.6	56	58.4
Freq. (Hz)	1600	2000	2500	3150	4000	5000
$R_{0,I}$	61.1	63.6	65	65	65	65
$R_{0,I,w}$ (dB)		**53**	**$R_{0,I,A}$** (dBA)		**52.7**	

Table 3.4: Sound reduction index values $R_{0,I}$ of the reference curve, for measurements with basic wall with low coincidence frequency

3.5.2 BASIC WALL WITH A MEDIUM COINCIDENCE FREQUENCY ("LIGHTWEIGHT BASIC WALL")

Homogeneous building element with a surface mass, *m*, of approximately 70 Kg/m^2, with a coincidence frequency on the 500 Hz octave band. The side on which the coating or lining is applied should be coated with gypsum plaster.

Freq. (Hz)	100	125	160	200	250	315
$R_{0,m}$	27	27	27	27	27	27
Freq. (Hz)	400	500	630	800	1000	1250
$R_{0,m}$	27	27	28	30.5	32.8	35.1
Freq. (Hz)	1600	2000	2500	3150	4000	5000
$R_{0,m}$	37.6	40	42.3	44.6	47.1	49.4
$R_{0,m,w}$ (dB)		**33**	**$R_{0,m,A}$** (dBA)		**33.4**	

Table 3.5: Sound reduction index values $R_{0,m}$ of the reference curve, for measurements with basic wall with medium coincidence frequency

3.6. WEIGHTED SOUND REDUCTION IMPROVEMENT INDEX BY ADDITIONAL LINING, ΔR_w

In Annex A of the *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*, ΔR_w is defined as the increase of weighted sound reduction index of a building element by applying a treatment or adding a coating to the basic building element. It is valued in terms of the difference between the weighted sound reduction index, R_w, of a reference building element with the improvement coating, and that of the reference building element per se.

According to Standard UNE-EN ISO 140-16:2007, in order to obtain the global value of the weighted sound reduction improvement index, ΔR_w, for a wall coating, it is necessary to use the reference curve, $R_{0,I}$, of table 3.4, or $R_{0,m}$, of table 3.5, depending on whether the measurement has been made on a reference basic wall with a low or medium coincidence frequency, respectively.

The ΔR_w value is obtained from the difference between the weighted sound reduction index obtained according to Standard UNE-EN ISO 717-1 (please refer to paragraph 3.3) pertaining to the $R_0+\Delta R$ and R_0 virtual curves:

$$\Delta R_w = (R_0 + \Delta R)_w - R_{0,w} \quad [dB]$$

where:

- $(R_0+\Delta R)_w$ is the weighted sound reduction index of the reference basic element with the coating, in dB.
- $R_{0,w}$ is the weighted sound reduction index of the reference basic element alone, in dB.

An additional sub-index indicates the reference basic element used: "heavy" for the reference wall with a low coincidence frequency, and "light" for the reference wall with a medium coincidence frequency.

3.7. A-WEIGHTED SOUND REDUCTION IMPROVEMENT INDEX BY ADDITIONAL LINING, ΔR_A

In Annex A of the *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*, ΔR_A is defined as the increase of weighted sound reduction index of a building element by applying a treatment or adding a coating to the basic building element. It is valued in terms of the difference between the A-weighted sound reduction index, R_A, of a reference building element with the improvement coating, and that of the reference building element per se.

In order to obtain the A-weighted sound reduction improvement index, ΔR_A, for a wall coating, it is necessary to use the reference curve, $R_{0,I}$, of table 3.4, or $R_{0,m}$, of table 3.5, depending on whether the measurement has been made on a reference basic wall with a low or medium coincidence frequency, respectively.

The value of ΔR_A is obtained from the difference between the values of the A-weighted sound reduction index (please refer to paragraph 3.2), pertaining to the $R_0+\Delta R$ and R_0 virtual curves:

$$\Delta R_A = (R_0 + \Delta R)_A - R_{0,A} \quad \text{[dBA]}$$

where:

- $(R_0+\Delta R)_A$ is the A-weighted sound reduction index of the reference basic element with the coating, in dBA.
- $R_{0,A}$ is the A-weighted sound reduction index of the reference basic element alone, in dBA.

Each reference curve leads to a different value for the improvement index:

- A-weighted sound reduction improvement index, pertaining to the reference curve with a low coincidence frequency, $\Delta R_{A,I}$;
- A-weighted sound reduction improvement index, pertaining to the reference curve with a medium coincidence frequency, $\Delta R_{A,m}$;

3.8. UNCERTAINTY OF THE RESULTS

The measurement uncertainty is computed as the typical measurement uncertainty multiplied by a coverage factor k=2, which corresponds to a 95% confidence level for a normal statistical distribution.

The expanded uncertainties of the results have been calculated and are listed below:

Freq. (Hz)	100	125	160	200	250	315
±U	1.9	2.9	1.6	2.4	1.5	1.2
Freq. (Hz)	400	500	630	800	1000	1250
±U	1.4	1.1	1.4	0.9	0.8	0.7
Freq. (Hz)	1600	2000	2500	3150	4000	5000
±U	1.0	1.1	1.3	1.2	1.5	0.8

Table 3.6: Expanded uncertainties of the results

4.- SAMPLE TESTED

To build the sample, a set of **Recfoam© U80** agglomerated polyurethane foam panels are used; they are 40 mm-thick and have a nominal density of 80 Kg/m^3. These panels are made by a special injection of polyurethane granulated powder and selective sieving (description is provided by the petitioner of the test). The nominal measurements of the panels are 2,000 x 1,000 mm. The material was received on 2nd March, 2009.

Images 1 and 2 – Details of the 40 mm Recfoam© U80 panels

As a sample, a vertical partition is built over a concrete frame (test frame), with an opening measuring 3.85 x 3 m, thus providing a sample surface of 11.55 m^2.

The partition basically consists of a basic wall built with ceramic brick measuring 280 x 140 x 95 mm (length x thickness x height), and an approximate mass of 4.4 Kg. The bricks are joined by M-7.5 mortar horizontal and vertical joint. The wall is finished off by applying on both sides an M-7.5 mortar coating measuring about 1.5 cm thickness.

Images 3, 4, 5 and 6 – Details of the wall

One of the sides of the wall is totally coated with 40 mm **Recfoam© U80** panel, which is glued to the wall with glue referred as Cola Copopren© D20. Panels are glued by applying with a spatula a coat of glue on the wall and another coat on the panels.

Images 7 and 8 – The panel is glued to the wall

Once the panels are installed, their whole surface is covered with a standard 18 mm-thick gypsum plasterboard, measuring 3,000 x 1,200 mm, and an estimated surface mass of 15 Kg/m^2. The plasterboards are glued to the panel with Cola Copopren© D20; a spatula is used to apply a coat of glue to the panels and to the plasterboards.

Images 9, 10 and 11 –Gypsum plasterboard is glued to the panel

The joint between the plasterboards is sealed with fixing paste, paper tape and joint paste for plasterboards. The perimeter joint between the plasterboards and the test frame is sealed with joint paste.

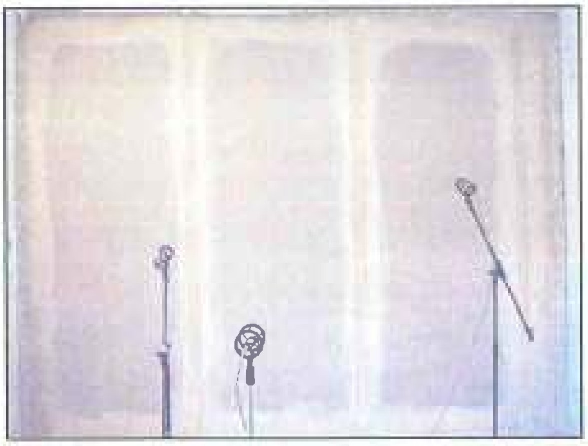
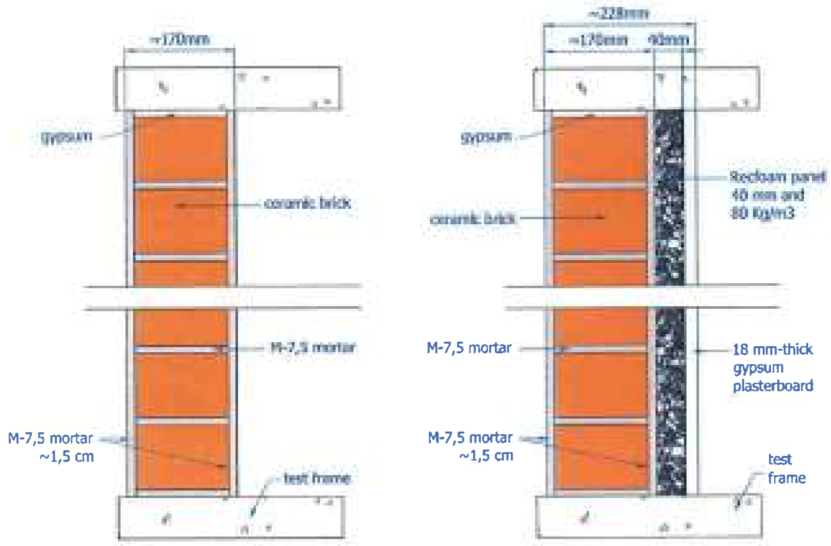


Imagen 12 Sample completed and ready for testing

In order to learn the sound insulation improvement provided by the described lining, the base wall alone is tested first, and a subsequent test is conducted on the whole set with the lining. The base wall has a total approximate thickness of 170 mm, and an estimated surface mass of 304 Kg/m^2. The whole set, with the installed lining, has an approximate total thickness of 228 mm and an estimated surface mass of 322 Kg/m^2.

The base wall is built on the test frame on 16th and 17th March, 2009 with the resources provided by Applus-CTC, and is lined on 31st March, 2009, with the help of subcontracted staff supervised by personnel from the Acoustics Laboratory.

The figures below show the sections of the tested constructions.



Figures 1 and 2 – Section of the base wall and of the wall with the lining

5.- TEST ENVIRONMENT

5.1. BASE WALL

	Source Room		Receiving Room	
Test environment:	Temperature:	12 ºC	Temperature:	12 ºC
	Rel. Humidity:	55 %	Rel. Humidity:	48 %
Volume of test rooms:		58.3 m^3		62.5 m^3

5.2. BASE WALL + LINING

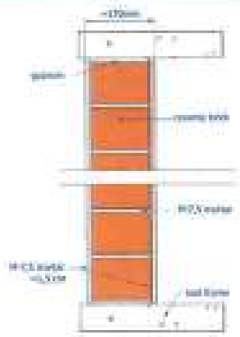
	Source Room		Receiving Room	
Test environment:	Temperature:	11 ºC	Temperature:	10 ºC
	Rel. Humidity:	71 %	Rel. Humidity:	70 %
Volume of test rooms:		58.3 m^3		61.7 m^3

6.- RESULTS

The results reported in this document relate only to the sample, product or item described above, having been tested under the conditions established in this document.

Airborne sound insulation in conformity with the standard UNE-EN ISO 140-3

Petitioner: RECTICEL IBÉRICA, S.L.



Sample tested:

Base wall made with ceramic bricks measuring 280 x 140 x 95 mm (length x thickness x height), and an approximate mass of 4.4 Kg. M-7.5 mortar coating measuring about 1.5 cm thickness on both sides.

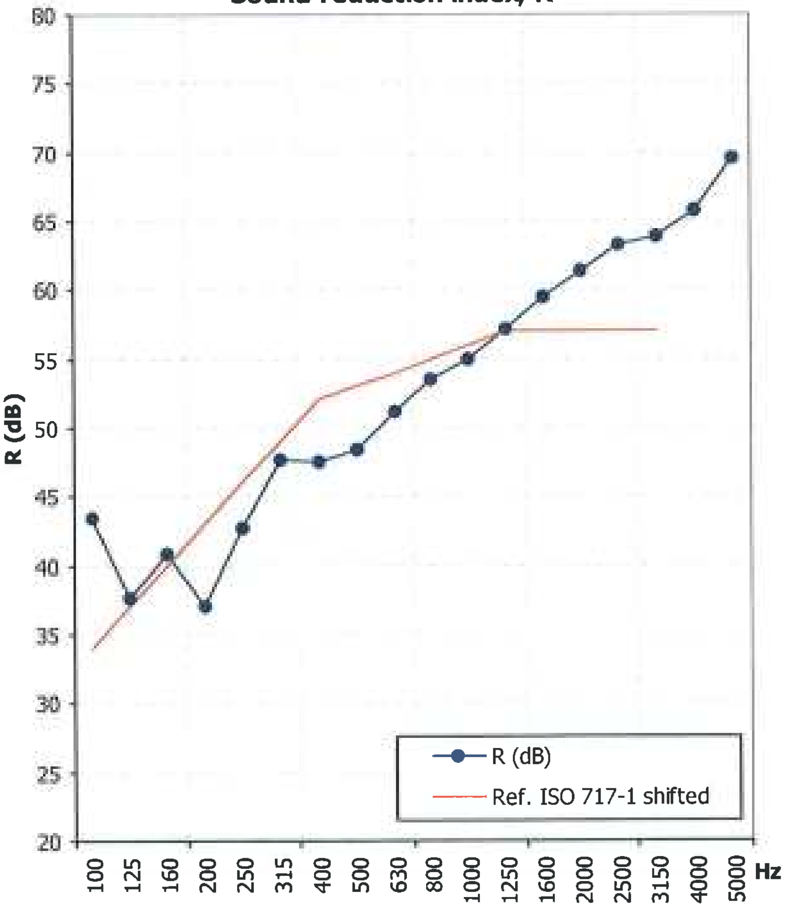
Surface mass, *m*, (estimated): 304 Kg/m^2

Sample surface, *S*: 11.55 m^2 (3.85 x 3 m)

Date test performed: 24th March, 2009

Frequency (Hz)	R (dB)
100	43.5
125	37.6
160	40.8
200	37.0
250	42.7
315	47.7
400	47.5
500	48.4
630	51.1
800	53.5
1000	54.9
1250	57.2
1600	59.5
2000	61.4
2500	63.3
3150	63.8
4000	65.7
5000	69.5

Sound reduction index, R

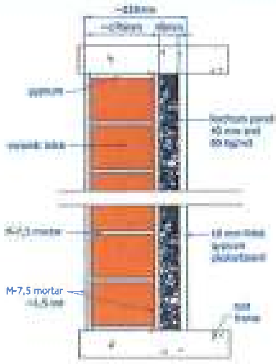


A-weighted sound reduction index A, **R$_A$** *:	**52.7 dBA**
Weighted sound reduction index, **R$_w$** (C; C$_{tr}$; C$_{100-5000}$; C$_{tr,100-5000}$)	**53 (-1; -5; 0; -5) dB**

* Index according to *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*

Airborne sound insulation in conformity with the standard UNE-EN ISO 140-3

Petitioner: RECTICEL IBÉRICA, S.L.



Sample tested:

Vertical partition composed by a ceramic brick wall 140 mm-thick coated (one side) with **Recfoam© U80** panel 40 mm-thick and 80 Kg/m^3 glued to the wall, and standard 18 mm-thick gypsum plasterboard. Everything is glued with glue referred as Cola Copopren© D20.

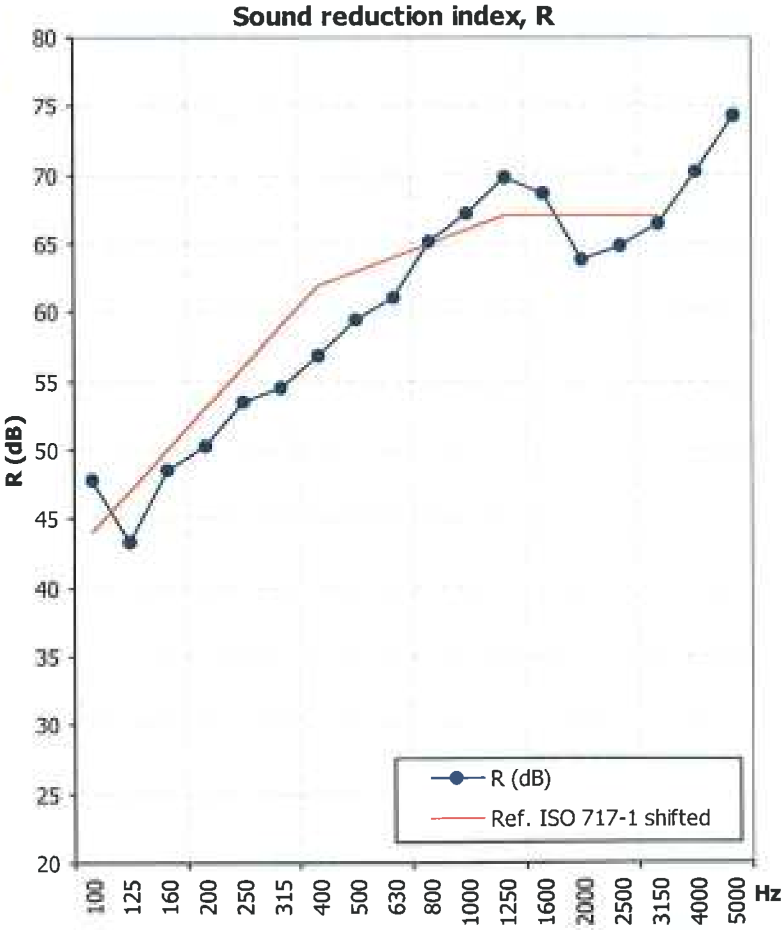
Surface mass, *m*, (estimated): 322 Kg/m^2

Sample surface, *S*: 11.55 m^2 (3.85 x 3 m)

Date test performed: 1st April, 2009

Frequency (Hz)	R (dB)
100	47.8
125	43.3
160	48.6
200	50.3
250	53.5
315	54.5
400	56.9
500	59.4
630	61.1
800	65.2
1000	67.2
1250	69.8
1600	68.7
2000	63.9
2500	64.9
3150	66.5
4000	70.3
5000	74.3

Sound reduction index, R



A-weighted sound reduction index A, $\mathbf{R_A}$*:	**62.0 dBA**
Weighted sound reduction index, $\mathbf{R_w}$ (C; C_{tr}; $C_{100\text{-}5000}$; $C_{tr,100\text{-}5000}$)	**62 (-1; -4; 0; -4) dB**

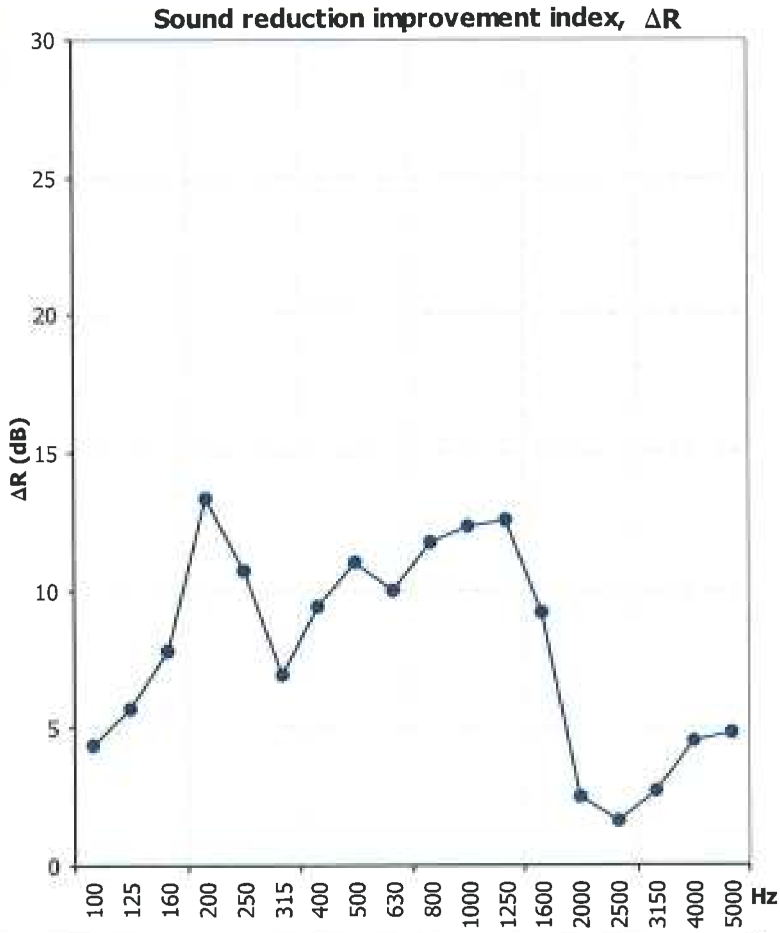
* Index according to *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*

7.- WEIGHTED SOUND REDUCTION INDEX IMPROVEMENTS

The weighted sound reduction index improvements are presented in this section. These improvements are due to the lining applied to the basic reference wall with low coincidence freq.

Basic element used	With the lining	Basic reference element	Basic reference element+ ΔR
R_w = 53 dB	R_w = 62 dB	$R_{0,w}$ = 53 dB	$(R_0 + \Delta R)_w$ = 63 dB
R_A = 52.7 dBA	R_A = 62.0 dBA	$R_{0,A}$ = 52.7 dBA	$(R_0 + \Delta R)_A$ = 61.5 dBA

Frequency (Hz)	ΔR (dB)
100	4.4
125	5.7
160	7.8
200	13.3
250	10.7
315	6.9
400	9.4
500	11.0
630	10.0
800	11.7
1000	12.3
1250	12.5
1600	9.2
2000	2.5
2500	1.6
3150	2.7
4000	4.5
5000	4.8



Weighted sound reduction improvement index, $\Delta R_{w,heavy}$:	**10 dB**
A-weighted sound reduction improvement index, $\Delta R_{A,I}$ *:	**8.8 dBA**

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* Index according to *Documento Básico "DB-HR Protección frente al ruido" del Código Técnico de la Edificación*