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

Applus+

ilac-MRA ENAC ENSAYOS Nº 9/LE766

Bellaterra:	27th May,2009
Expedient number:	09/32302042
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 09/32301771

REQUESTED TEST: Measurement of the airborne sound insulation in conformity with the standard UNE-EN ISO 140-3:1995 of a floating floor made with Recfoam© U150 panel 20 mm-thick and a 7 cm-thick concrete slab, installed over a reinforced concrete floor.

DATE TEST PERFORMED: 15th April, 2009

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

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

Quality Service Assurance

Applus+ guaranties that this work has been realized following the exigencies of our Quality and Sustainable System, complying with honoring the contractual conditions and the legal standard.
We would be very grateful if you would send us any comment you consider appropriate, addressing either to the signatory of this document or to the Applus+ Quality Director to the direction satisfaccion.cliente@appluscorp.com

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. This document shall not be reproduced except in full.
This document consists of 15 pages of which 0 are annexes.

LGAI Technological Center, S.A. Inscrita en el Registro Mercantil de Barcelona, Tomo 35 803, Folio 1, Hoja Nº B-266 627 Inscripcion 1ª C.I.F. A-63207492

1.- OBJECT OF MEASUREMENT

Measurement of the airborne sound insulation in conformity with the standard UNE-EN ISO 140-3:1995 of a floating floor made with Recfoam© U150 panel 20 mm-thick and a 7 cm-thick concrete slab, installed over a reinforced concrete floor.

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)
- Laser measurer nº id: 103196 (SKIL mod. Xact)

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:

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

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 ($C_{100-5000}$; $C_{tr,100-5000}$)

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:

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

For horizontal building elements a heavy homogeneous reinforced concrete floor in conformity with the standard UNE-EN ISO 140-8 (basic floor with low coincidence frequency, "heavy basic floor") is used as a basic element. However, the test can be done using as basic element the one which is going to be used in the real building.

freq. (Hz)	100	125	160	200	250	315
$R_{0,I}$	40,0	40,0	40,0	40,0	40,0	41,8
freq. (Hz)	400	500	630	800	1000	1250
$R_{0,I}$	44,4	46,8	49,3	51,9	54,4	56,8
Freq. (Hz)	1600	2000	2500	3150	4000	5000
$R_{0,I}$	59,5	61,9	64,3	65,0	65,0	65,0

$R_{0,I,w}$ (dB)	52	$R_{0,I,A}$ (dBA)	51,5

Table 3.4: Sound reduction index values $R_{0,I}$ of the reference curve, for measurements with basic floor with low 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 weighted sound reduction improvement index, ΔR_A, for a floor coating, it is necessary to use the reference curve $R_{0,I}$ of table 3.4.

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 $R_{0,I}+\Delta R$ and $R_{0,I}$ virtual curves:

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

where:

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

An additional sub-index indicates the basic element used: "heavy" for the basic with low coincidence frequency

3.6.1 DIRECT DIFFERENCE OF WEIGHTED SOUND REDUCTION INDEXES

In case of using as basic element a different one of the basic floor with low coincidence frequency, the only way to give a single number value is by calculating the direct difference between the weighted sound reduction indexes, $\Delta R_{w,direct}$, of the basic element with and without the lining.

$$\Delta R_{w,direct} = R_{w,with} - R_{w,without} \quad \text{[dB]}$$

3.7. A-WEIGHTED NOISE 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 floor coating, it is necessary to use the reference curve $R_{0,I}$ of table 3.4.

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 $R_{0,I}+\Delta R$ y $R_{0,I}$ virtual curves:

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

where:

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

If the test is done with a basic element different of basic floor with low coincidence frequency ("heavy basic floor"), the evaluation will be done with the A-weighted sound reduction index of the base building element used as a $R_{0,A}$.

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

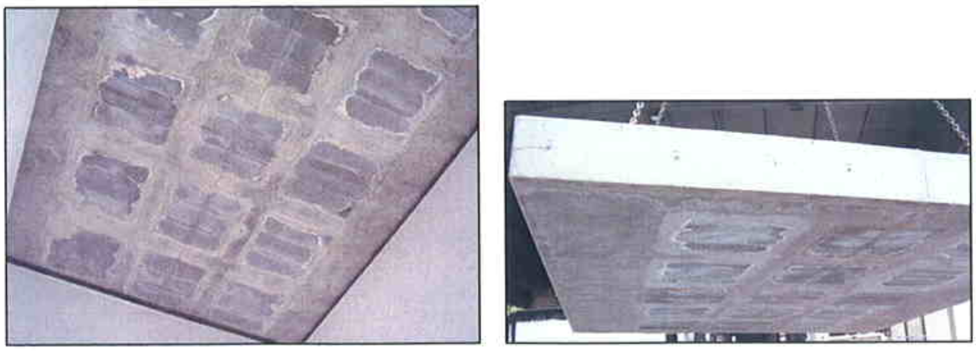
Table 3.5: Expanded uncertainties of the results

4.- SAMPLE TESTED

To build the sample, a set of **Recfoam© U150** agglomerated polyurethane foam panels are used; they are 20 mm-thick and have a nominal density of 150 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 20 mm Recfoam© U150 panels

The sample basically consists of a reinforced concrete floor HA-25/B/20/IIa of 30 cm (25+5) thickness with no recoverable concrete caissons, 15 cm ribs width and 85x85 cm grid.



Images 3 and 4 - Reinforced concrete floor

Over the concrete floor a floating floor is installed and its surface, 13.44 m^2, is determinate by the source room surface 4.2 x 3.2 m (which is the same as receiving room surface). Upper side of the concrete floor is totally coated with 20 mm **Recfoam© U150** panel.

Images 5, 6 and 7 - The panel is placed over the basic concrete floor

When the panels have been placed, a concrete slab of 7 cm thickness and estimated surface mass 147 Kg/m^2 is installed over they.

Images 8 and 9 – Concrete slab and its installation over Recfoam© U150 panel

In order to learn the sound insulation improvement provided by the described floating floor, the basic floor alone is tested first, and a subsequent test is conducted on the whole set with the floating floor.

The basic floor has a total approximate thickness of 300 mm, and an estimated surface mass of 513 Kg/m^2. The whole set, with the installed floating floor, has an approximate total thickness of 390 mm and an estimated surface mass of 663 Kg/m^2.