REPORT No. B2022-LACUS-IN-176 A_En

CLIENT: **SUSPENSIONES ELÁSTICAS DEL NORTE, S.L. (SENOR)**

Polígono industrial El Garrotal, Parcela 10 - Módulos 4 y 5
14700 Palma del Río, Córdoba, España

AIM: **Laboratory measurement of improvement of airborne and impact sound insulation**

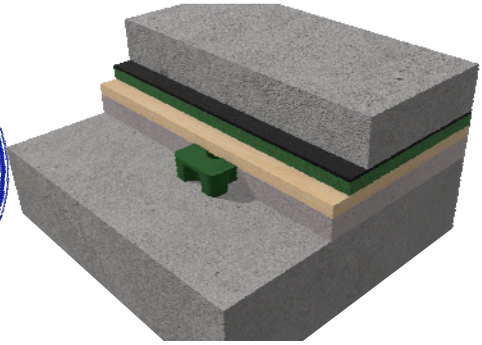
STANDARDS: **EN ISO 10140-1:2021-Annex G**
EN ISO 10140-2:2021
EN ISO 10140-1:2021-Annex H
EN ISO 10140-3:2021

TEST SPECIMEN: **CONCRETE ACOUSTIC FLOOR (SENOR+ChovA):**
- SE-TS-80 V 150 damper (SENOR)
- ChovANAPA 4 cm PANEL 600 (ChovA)
- SE-BEC-15x170 acoustic strip (SENOR)
- 16 mm DM board
- ChovACUSTIC 65 FIELTEX (ChovA)
- 60 mm reinforced concrete

ORIGINAL REPORT ISSUE DATE: **7th October 2022** TRANSLATION DATE: **7th October 2022**

Technical Consultant
Susana Lopez de Aretxaga

LAB_SERVICES



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- This document is the English version of the original report issued in Spanish, B2022-LACUS-IN-176 A-M1 (7th October 2022). In case of lawsuit, the original version shall prevail.
- The results of the current report concern only and exclusively the test specimen.
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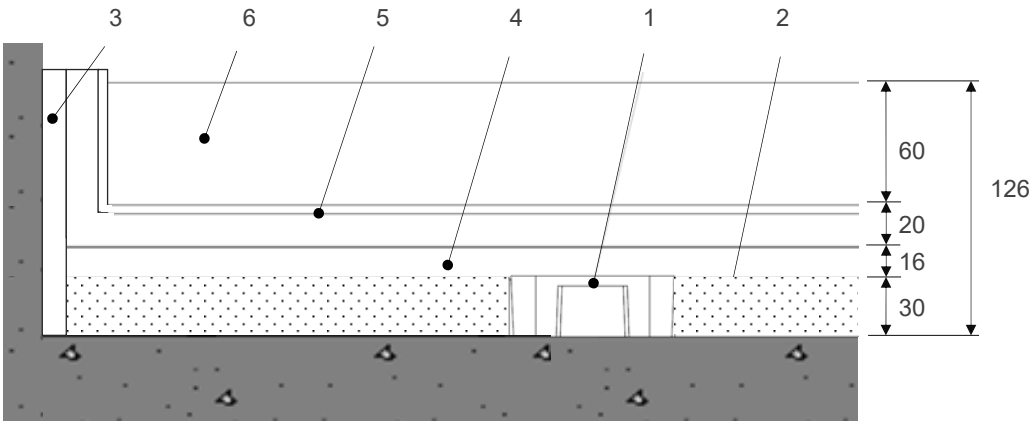
1. TEST SPECIMEN DESCRIPTION

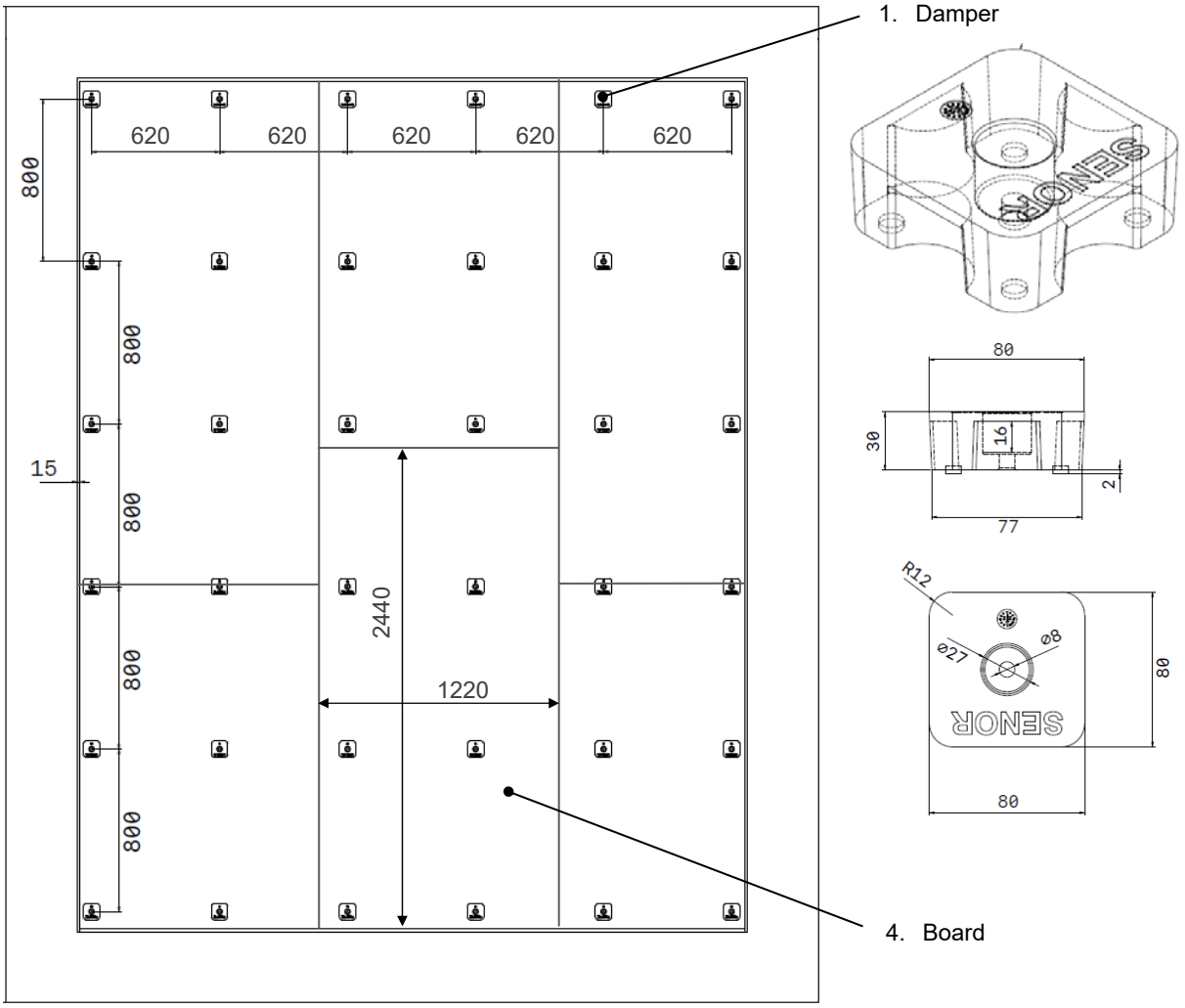
The test specimen consists of a floor covering, with the following composition according to the information provided by the applicant:

Laboratory test specimen code: B2022-175-M898



Sketch 1 – Vertical section. Cotes in mm

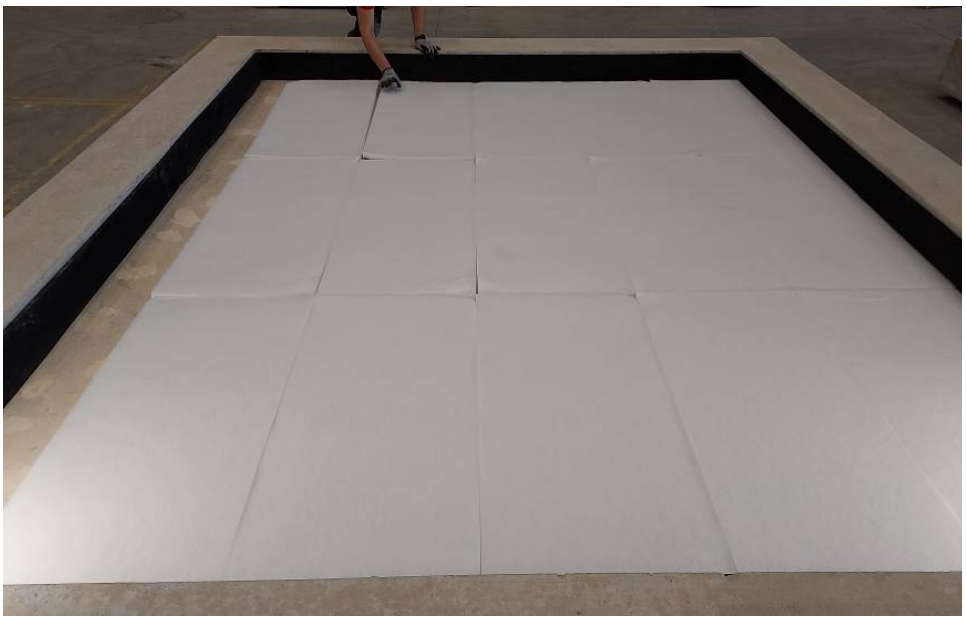
1. SE-TS-80 V 150 damper (SENOR): "TC4/GPN" polymeric damper, 80x80 mm and 30 mm thick. Arranged on the floor.
2. ChovANAPA 4 cm PANEL 600 (ChovA): Polyester fiber (40 mm thick and 14 kg/m^3). 1 layer of panels arranged on the floor and between dampers, butt jointed each other.
3. SE-BEC-15x170 strip (SENOR): EPDM CR-130 Microcellular self-adhesive acoustic strip (15 mm thick x 170 mm wide). Adhered to the perimeter.
4. 16 mm DM board: DM board 1220x2440x16 mm thick and 12,1 kg/m^2.
5. ChovACUSTIC 65 FIELTEX (ChovA): Multilayer compound composed by textile felt thermally adhered to a high-density viscoelastic sheet of 4 mm. 20 mm thick and 6,8 kg/m^2 of estimated superficial mass. 1 m wide format. Arranged on DM board, with felt against DM board and tongue and groove joint (35 mm) between sections.
6. 60 mm reinforced concrete: Concrete slab, with washed sand-cement dosage of 4-1, poured on the multilayer compound and against perimeter, with steel mesh of 15 x 15 cm and ø5 mm.

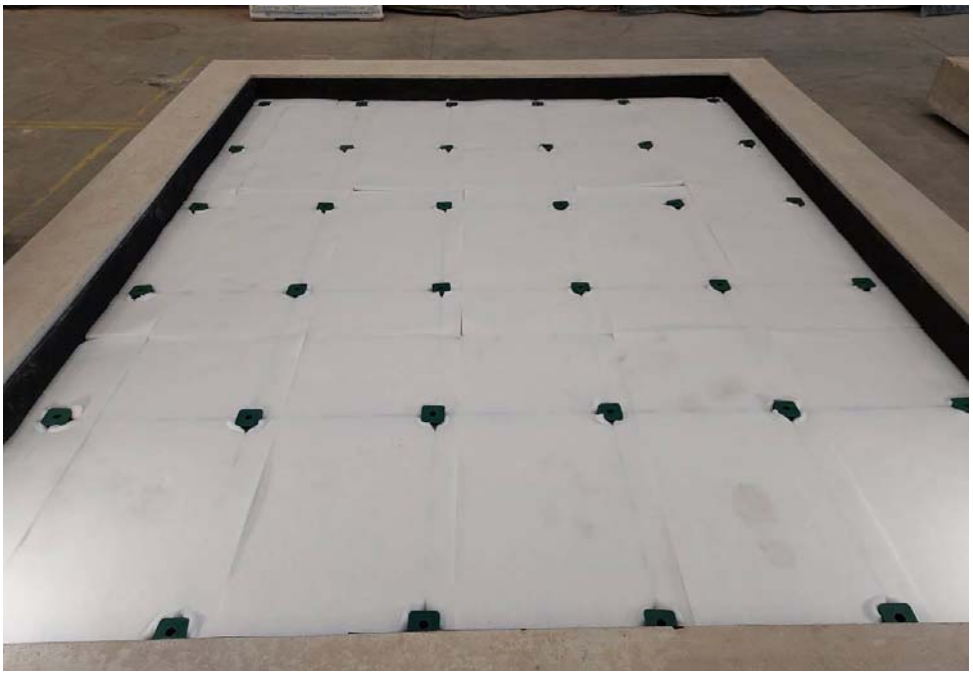


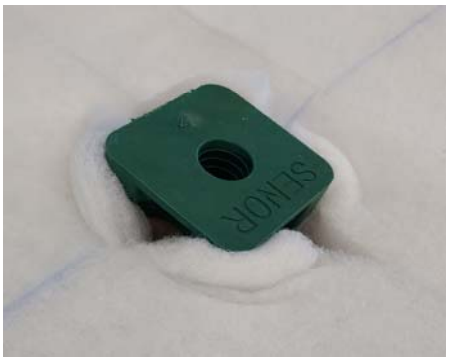
- Boards arranged on the dampers, butt jointed each other and against SE-BEC strip.
- Joints between boards and perimeter joint between boards and SE-BEC strip, sealed with silicone.

Sketch 2 – Arrangement of dampers and DM boards. Cotes in mm

Photos of damper



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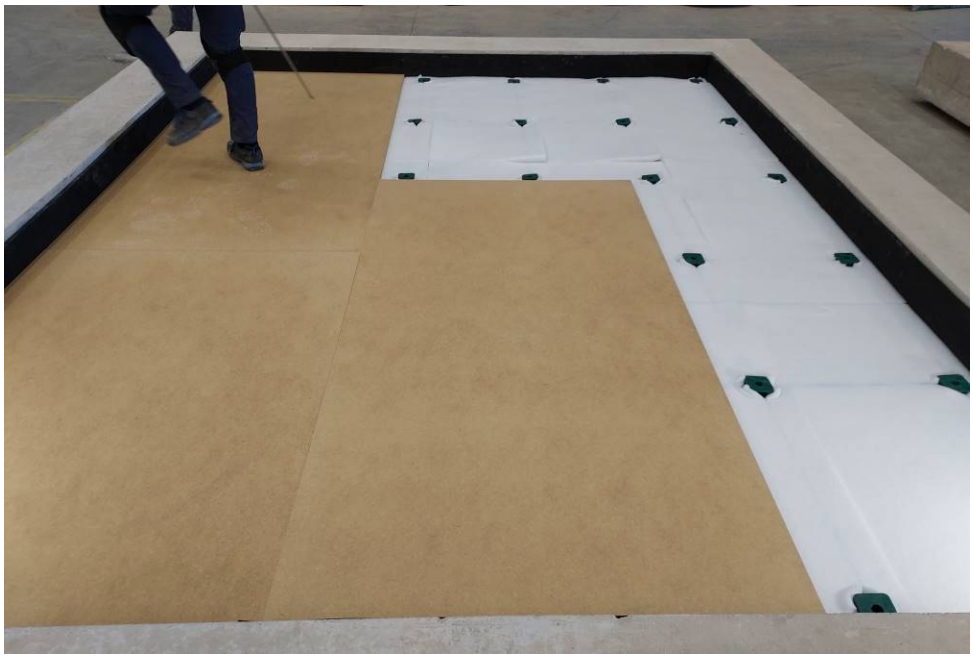


Photos of assembly of test specimen

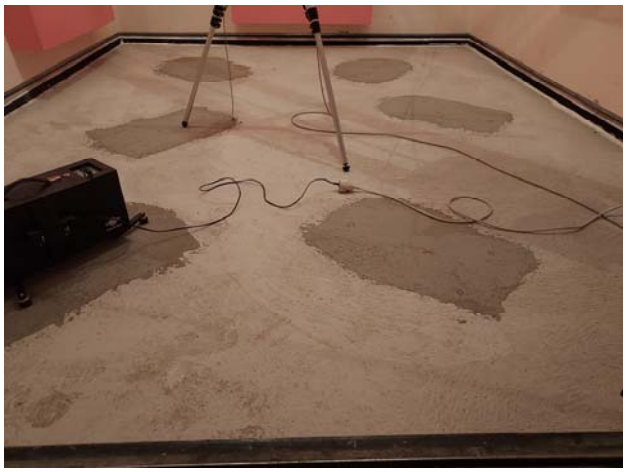


Photo of test specimen in the acoustic room

Test arrangement:

Test specimen placed on the heavyweight reference floor, provided by the laboratory in its final condition.

Tested specimen dimensions: 4,2 x 3,3 m (Surface 13,86 m^2).

Floor covering Category II, according to EN ISO 10140-1:2021.

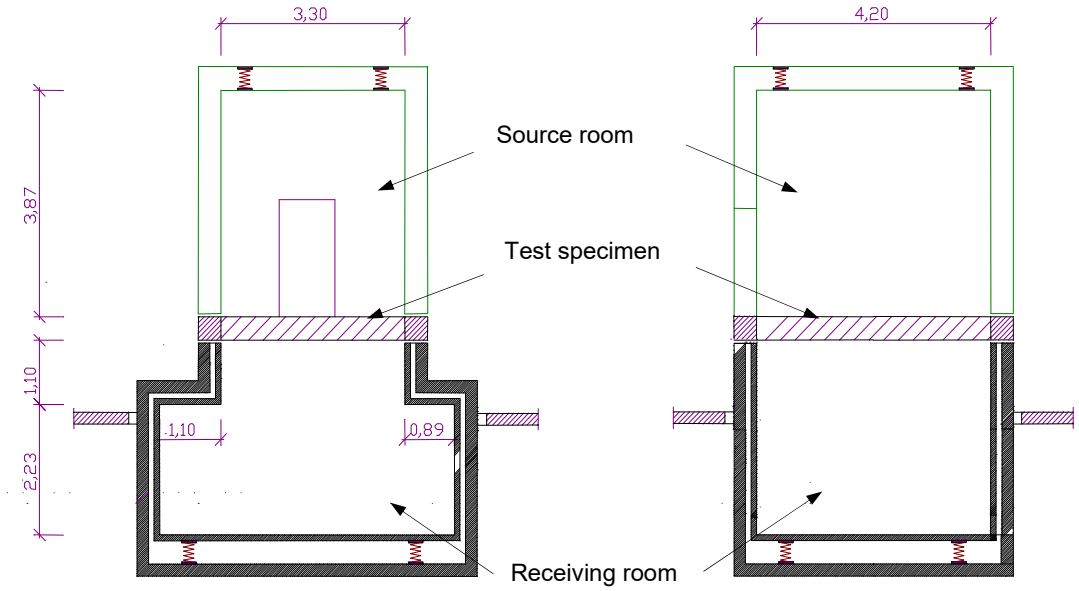
Material delivered by: SENOR, its referenced material in test specimen description and DM board, Asfaltos Chova, S.A (ChovA), its referenced material in test specimen description and Construcciones J.L. Iglesias, the concrete and mesh for the slab.

Assembly performed by: SENOR and Construcciones J.L. Iglesias (mesh and slab pouring).

Assembly end date: 17th May 2022

2. TEST FACILITIES

The test is performed in the vertical transmission rooms of the laboratory, composed of a source and a receiving room. The receiving room is formed by a concrete outer enclosure of 20 cm of thickness and a concrete inner enclosure of 10 cm of thickness, both acoustically disconnected. The source room, of 40 cm of thickness, is formed by a double enclosure of metal profile and gypsum board, both acoustically disconnected. The mobility of the source room allows the assembly of the test specimen outside and its later movement into the test rooms. Laboratory test facilities comply with the requirements of EN ISO 10140-5:2021.



Sketch of vertical transmission acoustic rooms

3. EQUIPMENT AND TEST CONDITIONS

Equipment

Microphones	Brüel&Kjær 4943; Serie No. 3188436	Brüel&Kjær 4943; Serie No. 3188435
Preamplifiers	Brüel&Kjær 2669; Serie No. 1948764	Brüel&Kjær 2669; Serie No. 2025844
Sound sources	Brüel&Kjær 4296; Serie No. 2071420	CERWIN VEGA; No. Nº 012446
Booms	Brüel&Kjær 3923; Serie No. 2036584	Brüel&Kjær 3923; Serie No. 2036585
Tapping machine	Brüel&Kjær 3207; Serie No. 02675448	
Analyser	Nor850-MF1; Serie No. 8501186	
Amplifier	LAB 300; 970-967	
Equalizer	Sony, SRP-E100; Serie No. 400238	
Calibrator	Brüel&Kjær 4231; Serie No. 2061476	
Atmospheric conditions meter	Rotronic BL-1D; Serie No. A19060062 Measurement uncertainty: T (± 0,5 ºC), H (±4 %), P (±2 mbar) T: Air temperature; H: Relative humidity; P: Static pressure	
Test specimen temperature meter	TC Direct 401-215 type T s/n - 05LA0T003	

4. TEST PROCEDURE AND EVALUATION

4.1 Improvement of airborne sound insulation

The improvement of airborne sound insulation of a lining is characterized by the sound reduction improvement index (ΔR). For its determination, the measurement of airborne sound insulation is performed according to EN ISO 10140-2:2021, both for the basic element (heavyweight reference floor specified in EN ISO 10140-5:2021-Annex B) and the basic element + lining.

The sound reduction improvement index (ΔR) of a lining placed on a basic element, for the one-third octave band from 100 Hz to 5 kHz, is obtained according to standard EN ISO 10140-1:2021-Annex G, as the difference between the sound reduction indices of the basic element with and without the lining, as detailed in the equation:

$$\Delta R = R_{with} - R_{without}$$

R_{with}: Sound reduction index of the basic element with lining, from 100 to 5000 Hz

$R_{without}$: Sound reduction index of the basic element without lining, from 100 to 5000 Hz

The sound reduction index, R, for the one-third octave band from 100 Hz to 5 KHz is calculated according to EN ISO 10140-2:2021 using the following formula:

$$R=L_1-L_2+10*\text{Log } S/A$$

L_1: Average sound pressure level in the source room

L_2: Average sound pressure level in the receiving room

S: Test specimen area

A: Equivalent sound absorption area in the receiving room

The measurement of the average sound pressure levels L_1 and L_2, is performed by emitting an equalized white noise, from 100 Hz to 5 kHz, using a moving omnidirectional sound source. The sound field in the source and receiving rooms is sampled using a moving microphone with a sweep radius of 1 m and a traverse period of 16 s during 32 s of measure, for the basic element and through six fixed positions of the microphone path, for the basic element with lining. Background noise in the receiving room for the one-third-octave band from 100 Hz to 5 KHz, is measured according to the same measurement process of sound field in the receiving room.

The equivalent sound absorption area for the one-third octave band from 100 Hz to 5 kHz is evaluated from the reverberation time measured in the receiving room, using Sabine's formula:

$$A=0,16*V/T$$

A: Equivalent sound absorption area in the receiving room

T: Reverberation time in the receiving room

V: Receiving room volume

Reverberation time in the receiving room is determined by using two positions of the sound source and three fixed microphone positions for each source position distributed at 120º in the microphone path.

Measuring chain is verified just before and after the execution of the test.

The guidelines indicated in the applicable internal procedures have been followed:

- PE.CM-AA-61-E: “Procedure for the determination of the airborne sound insulation into the horizontal and vertical transmission rooms”.
- PE.MC-AA-06-M: “Procedure to manage the test specimens for acoustic tests in laboratory”.

4.2 Improvement of impact sound insulation

The improvement of impact sound insulation of a floor covering is defined by the Reduction of impact sound pressure level (ΔL). Its determination requires the impact sound insulation test of the heavyweight reference floor specified by EN ISO 10140-5: Annex C, with and without the floor covering, according to standard EN ISO 10140-3:2021.

The reduction of impact sound pressure level, ΔL, in decibels, of the floor covering at one-third octave frequency band is obtained from the difference between normalized impact sound pressure levels of the heavyweight reference floor without and with the floor covering:

$$\Delta L = L_{n,0} - L_n$$

$L_{n,0}$: Normalized impact sound pressure level of the heavyweight reference floor without floor covering, between 100 and 5000 Hz.

L_n: Normalized impact sound pressure level of the heavyweight reference floor with floor covering, between 100 and 5000 Hz.

Both levels ($L_{n,0}$ and L_n) at each one-third octave frequency band between 100 Hz and 5 KHz, are obtained according to the following formula:

$$L_{n,0} = L_i + 10 * \text{Log } A/A_0 \; ; \; L_n = L_i + 10 * \text{Log } A/A_0$$

L_i: Impact sound pressure level

A: Equivalent absorption area in the receiving room

A_0: Reference equivalent absorption area (10 m^2)

The measurement of the impact sound pressure level, L_i, in a one-third-octave band in the receiving room is performed by exciting the sample using a standard tapping machine, placed at six positions randomly distributed on the test specimen. For each position, the sound field in the receiving room is sampled using a moving microphone with a sweep radius of 1 m and a traverse period of 16 s during 32 s of measure. The impact sound pressure level for the test specimen is obtained as the average of the measured impact sound pressure levels. To determinate L_n and L_{n0}, the same positions of the standard tapping machine are used. The standard tapping machine has five metallic hammers of 30 mm of nominal diameter and meets the specifications of EN ISO 10140-5:2021, Annex E.

The background noise is measured in the receiving room in the one-third-octave band 100 Hz to 5 kHz, according to the same measurement process of sound field in the receiving room.

The equivalent sound absorption area between 100 Hz and 5 kHz, is evaluated from the reverberation time measured in the receiving room, using Sabine’s formula:

$$A = 0{,}16 * V/T$$

A: Equivalent sound absorption area in the receiving room
T: Reverberation time in the receiving room
V: Receiving room volume

The reverberation time in the receiving room is determined using two positions of the sound source and three fixed microphone positions for each source position, at 120º in the microphone path.

Measuring chain is verified just before and after the execution of the test.

The guidelines indicated in the applicable internal procedures have been followed:

- PE.CM-AA-62-E: “Procedure to determinate the impact sound insulation and the improvement of impact sound insulation in the vertical transmission room”.
- PE.MC-AA-06-M: “Procedure to manage the test specimens for acoustic tests in laboratory”.

5. RESULTS

5.1 Improvement of airborne sound insulation

The following results are presented:

- Sound reduction improvement index, ΔR, in decibels, for the one-third-octave band from 100 Hz to 5000 Hz, in table and graph.
- Weighted sound reduction improvement index, $R_{w\ heavy}$, calculated according to EN ISO 717-1:2020, on the heavyweight reference floor.

$$\Delta R_{w,heavy} = R_{w,ref,with} - R_{w,ref,without}$$

$R_{ref,with} = R_{ref,without} + \Delta R$

$R_{ref,without}$ given in EN ISO 717-1:2020, Annex E

- A-weighted improvement of sound reduction indices $\Delta(R_w+C)_{heavy}$ and $\Delta(R_w+C_{tr})_{heavy}$, calculated in an equivalent way.
- A-weighted improvement of sound reduction indices from 100 to 5000 Hz, $\Delta R_A=\Delta(R_w+C_{100\text{-}5000})_{heavy}$ and $\Delta R_{A,tr}=\Delta(R_w+C_{tr,100\text{-}5000})_{heavy}$, calculated in an equivalent way.

Additionally, are presented:

- Sound reduction index of the heavyweight reference floor, R_{with}, for the one-third-octave band from 100 Hz to 5000 Hz.
- Sound reduction index of the heavyweight reference floor, $R_{without}$, for the one-third-octave band from 100 Hz to 5000 Hz.
- Global indices R_w (C; C_{tr}), R_A and $R_{A,tr}$ for both elements mentioned above, calculated as follows:
  - R_w: Weighted sound reduction index, calculated according to EN ISO 717-1:2020, from the sound reduction index, R.

- C and C_{tr}: Spectrum adaptation terms from 100 to 3150 Hz, calculated according to EN ISO 717-1:2020, which are the values, expressed in decibels, to be added to the global magnitude value R_w to consider the characteristics of the pink noise spectrum (C) and traffic noise spectrum (C_{tr}), respectively.
- R_A and $R_{A,tr}$: Global indices calculated according to the expression of *Documento Básico "DB-HR Protección frente al ruido" - Código Técnico de la Edificación (CTE)*, from the sound reduction index, R, obtained by laboratory measurement:
  - R_A: A-weighted sound reduction index, from 100 to 5000 Hz, expressed to one decimal place.
  - $R_{A,tr}$: A-weighted sound reduction index for exterior traffic noise, from 100 to 5000 Hz, expressed to one decimal place.

The R value marked with * means that is greater than or equal to the indicated value, due to the approximation in less than 15 dB for the R'_{max} of the test facilities. The ΔR value marked with * means that is greater than or equal to the indicated value, due to the measurement limit of the R value marked with * on the corresponding frequency. The global index marked with ** means that is greater than or equal to indicated value, due to the limit values in frequencies marked with *.

F(Hz)	100	125	160	200	250	315	400	500	630
R'_{max} (dB)	61,2	63,7	72,6	67,6	76,3	79,5	84,9	89,2	93,4
F(Hz)	800	1000	1250	1600	2000	2500	3150	4000	5000
R'_{max} (dB)	95,3	97,4	97,7	99,0	99,6	96,4	92,3	84,8	81,5

5.2 Improvement of impact sound insulation

The following results are presented for the test specimen:

- The reduction of impact sound pressure level (ΔL) at one-third octave frequency band between 100 and 5000 Hz, in table and graph.
- The weighted reduction of impact sound pressure level (ΔL_w) of the floor covering, according to EN ISO 717-2:2020, obtained using the following formula:

$$\Delta L_w = L_{n,r,0,w} - L_{n,r,w} = 78\ dB - L_{n,r,w}$$

$L_{n,r,0,w}$: Weighted normalized impact sound pressure level calculated from $L_{n,r,0}$

$L_{n,r,w}$: Weighted normalized impact sound pressure level calculated from $L_{n,r}$

$L_{n,r,0}$: Normalized impact sound pressure level of a reference floor defined in the standard EN ISO 717-2:2020

$L_{n,r,}$: Normalized impact sound pressure level calculated by $L_{n,r} = L_{n,r,0} - \Delta L$.

- The spectrum adaptation term ($C_{I,\Delta}$), according to EN ISO 717-2:2020, obtained using the following formula:

$$C_{I,\Delta} = C_{I,r,0} - C_{I,r} = -11\ dB - C_{I,r}$$

$C_{I,r,0}$: Spectrum adaptation term calculated from $L_{n,r,0}$

$C_{I,r}$: Spectrum adaptation term calculated from $L_{n,r}$

Additionally, the following information is presented:

- Normalized impact sound pressure level of the floor covering on the heavyweight reference floor (L_n) between 100 and 5000 Hz.
- Normalized Impact sound pressure level of the heavyweight reference floor ($L_{n,0}$) between 100 and 5000 Hz.
- Single-number quantities ($L_{n,w}$ and $L_{n,0,w}$) of the heavyweight reference floor with and without the floor covering and Single-number quantity ($L_{n,r,w}$) and spectrum adaptation term ($C_{I,r}$).

The L_n value marked with * means that is less than or equal to the indicated value, due to the approximation of receiving level for the background noise in less than 6 dB (1,3 dB has been made for background correction). The ΔL value marked with * means that is greater than or equal to the indicated value, due to the measurement limit of the L_n value marked with * in the corresponding frequency.

Sound reduction improvement index of a lining on heavyweight reference floor according to EN ISO 10140-1:2021-Annex G
Laboratory measurements according to EN ISO 10140-2:2021

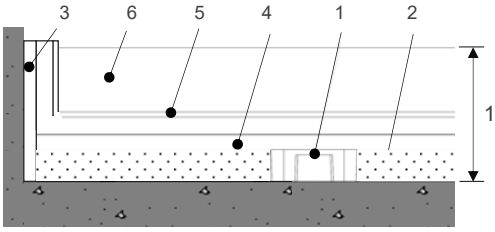
CLIENT: **SUSPENSIONES ELÁSTICAS DEL NORTE, S.L. (SENOR)**

TEST DATE: 15th June 2022

RESULT No: B2022-176-M898 MRA

TEST SPECIMEN: **CONCRETE ACOUSTIC FLOOR (SENOR+ChovA):**
- SE-TS-80 V 150 damper (SENOR)
- ChovANAPA 4 cm PANEL 600 (ChovA)
- SE-BEC-15x170 acoustic strip (SENOR)
- 16 mm DM board
- ChovACUSTIC 65 FIELTEX (ChovA)
- 60 mm reinforced concrete

Test specimen estimated superficial mass: 170 kg/m^2
Test specimen area, S: 13,86 m^2 (3,3x4,2m)

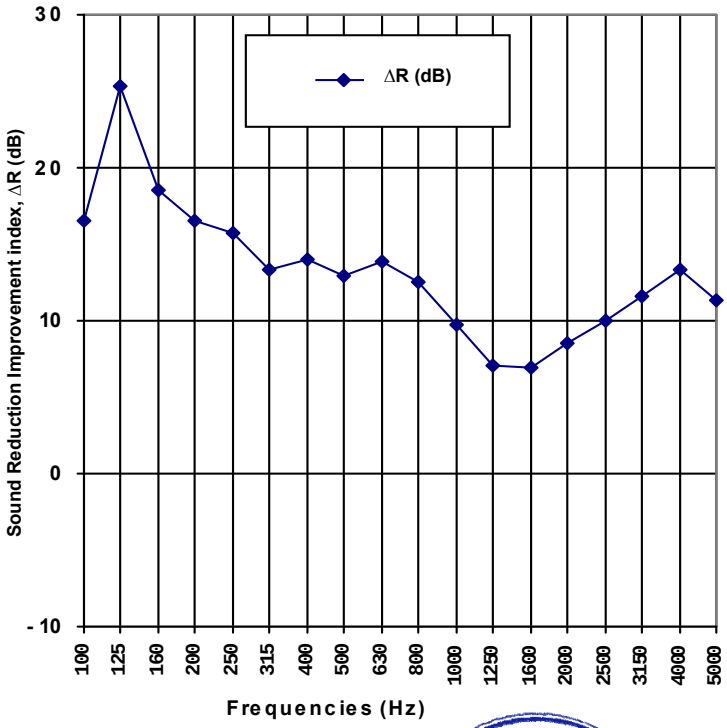


1. SE-TS-80 V 150 damper
2. ChovANAPA 4 cm PANEL 600
3. SE-BEC-15x170 strip
4. 16 mm DM board
5. ChovACUSTIC 65 FIELTEX
6. 60 mm reinforced concrete

Heavyweight reference floor: Reinforced concrete slab of 150 mm (375 kg/m^2), tested on 4th May 2022 ($R_{without}$).

V_{src}: 54,6 m^3; T_{src}: 21,3 ºC; H_{src}: 70 %; P_{src}: 960 mbar
V_{rec}: 64,7 m^3; T_{rec}: 20,3 ºC; H_{rec}: 74 %; P_{rec}: 960 mbar
V: volume; src: source room; rec: receiving room

f (Hz)	R_{with} (dB)	$R_{without}$ (dB)	ΔR (dB)
100	56,6 *	40,0	16,6 *
125	61,0 *	35,7	25,3 *
160	59,6 *	41,1	18,5 *
200	64,6 *	48,1	16,5 *
250	64,6 *	48,9	15,7 *
315	66,0 *	52,6	13,4 *
400	68,9	54,9	14,0
500	69,7	56,7	13,0
630	71,6	57,7	13,9
800	71,5	59,0	12,5
1000	70,8	61,1	9,7
1250	70,0	62,9	7,1
1600	72,2	65,2	7,0
2000	76,9	68,4	8,5
2500	81,4	71,4	10,0
3150	86,3 *	74,7	11,6 *
4000	89,9 *	76,5 *	13,4 *
5000	90,6 *	79,3 *	11,3 *



$R_w(C; C_{tr})_{with}$: 72(-1;-3) dB **	$R_w(C; C_{tr})_{without}$: 59(-2; -7) dB
$R_{A,with}$: 72,3 dBA **	$R_{A,without}$: 57,5 dBA
$R_{A,tr,with}$: 68,6 dBA **	$R_{A,tr,without}$: 51,7 dBA

Rating according to EN ISO 717-1:2020:

$\Delta R_{w,heavy}$: 12 dB ** / $\Delta(R_w+C)_{heavy}$: 13 dB ** / $\Delta(R_w+C_{tr})_{heavy}$: 15 dB **

$\Delta R_A=\Delta(R_w+C_{100-5000})_{heavy}$: 13 dB ** / $\Delta R_{A,tr}=\Delta(R_w+C_{tr,100-5000})_{heavy}$: 15 dB **

** R' and ΔR ≥ indicated value (measurement limit by approx. R'max). ** Global index ≥ indicated value.*

Evaluation based on laboratory measurement obtained by an engineering method.

Reduction of Impact Sound Pressure Level of a lining on heavyweight reference floor according to EN ISO 10140-1:2021-Annex H
Laboratory measurements according to EN ISO 10140-3:2021

CLIENT: **SUSPENSIONES ELÁSTICAS DEL NORTE, S.L. (SENOR)**

TEST DATE: 15th June 2022

RESULT No.: B2022-176-M898 MRI

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Test specimen estimated superficial mass: 170 kg/m^2
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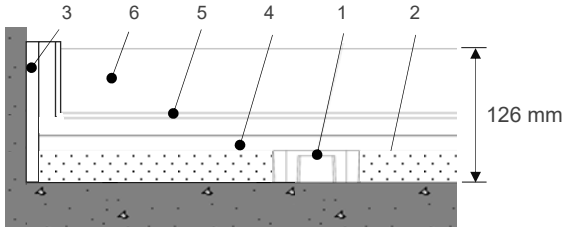
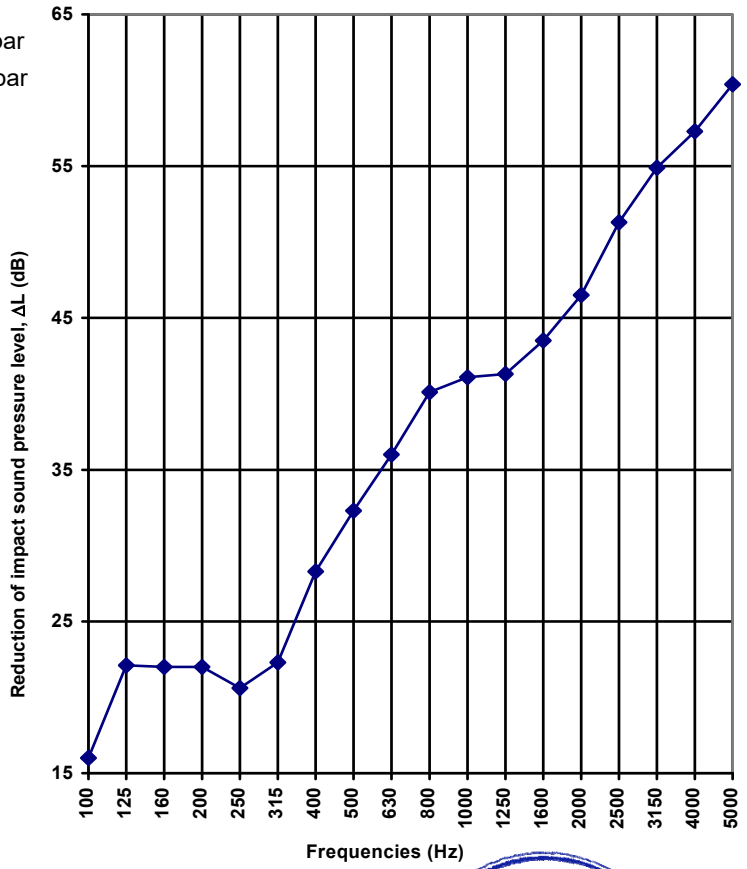


1. SE-TS-80 V 150 damper
2. ChovANAPA 4 cm PANEL 600
3. SE-BEC-15x170 strip
4. 16 mm DM board
5. ChovACUSTIC 65 FIELTEX
6. 60 mm Reinforced concrete

Heavyweight reference floor: Reinforced concrete slab of 150 mm (375 kg/m^2), tested on 4th May 2022 ($L_{n,0}$).

V_{src}: 54,6 m^3; T_{src}: 21,3 ºC; H_{src}: 70 %; P_{src}: 960 mbar
V_{rec}: 64,7 m^3; T_{rec}: 20,3 ºC; H_{rec}: 74 %; P_{rec}: 960 mbar
$T_{upper\ floor\ surface\ centre}$: 21,6 ºC
V: volume; src: source room; rec: receiving room

f (Hz)	$L_{n,0}$ (dB)	L_n (dB)	ΔL (dB)
100	62,0	46,0	16,0
125	64,6	42,5	22,1
160	64,3	42,3	22,0
200	62,2	40,2	22,0
250	63,5	42,9	20,6
315	63,7	41,4	22,3
400	64,3	36,0	28,3
500	66,2	33,9	32,3
630	67,2	31,2	36,0
800	69,6	29,5	40,1
1000	69,9	28,8	41,1
1250	70,1	28,8	41,3
1600	70,1	26,6	43,5
2000	70,0	23,5	46,5
2500	69,6	18,3	51,3
3150	69,3	14,4 *	54,9 *
4000	69,4	12,1 *	57,3 *
5000	69,1	8,7 *	60,4 *



Rating according to EN ISO 717-2:2020: **ΔL_w ($C_{I,\Delta}$): 37 (-11) dB**

$L_{n,0,w}$: 76 dB; $L_{n,w}$: 36 dB; $L_{n,r,w}$: 41 dB; $C_{I,r}$: 0 dB

** L_n ≤ indicated value (measurement limit by approx. background noise. ΔL ≥ indicated value.*

These results are based on test made with an artificial source under laboratory conditions (engineering method).