Razón Social / FUNDACIÓN TECNALIA RESEARCH & INNOVATION Nº F-69 Registro de Fundaciones del Gobierno Vasco CIF G48975767

TEST REPORT No. 110860-861 A-E

CLIENT: **SUSPENSIONES ELÁSTICAS DEL NORTE, S.L. (SENOR)**
Polígono industrial El Garrotal, Parcela 10 - Módulos 4 y 5
14700 Palma del Río, Córdoba, Spain

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: **ACOUSTIC DIRECT SUSPENDED CEILING DANOSA+SENOR:**

- DANOFON (DANOSA)
- SE-FTD MINI 47 dampers (SENOR)
- 45 mm profile
- FONODAN 50 (DANOSA) and SE-MONT BICAPA 40 (SENOR)
- SE-BEC-8x80 acoustic strip (SENOR)
- 12,5 mm plasterboard
- M.A.D. 4 (DANOSA)
- 12,5 mm plasterboard

ORIGINAL REPORT ISSUE DATE: **09/01/2025** TRANSLATION DATE: **25/06/2025**

Technical Consultant
Susana Lopez de Aretxaga

LAB_SERVICES

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- The results of the current report concern only and exclusively the test specimen.
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- Test specimen reference provided by the client. TECNALIA is not responsible for the information provided by the client. This information is not accredited.

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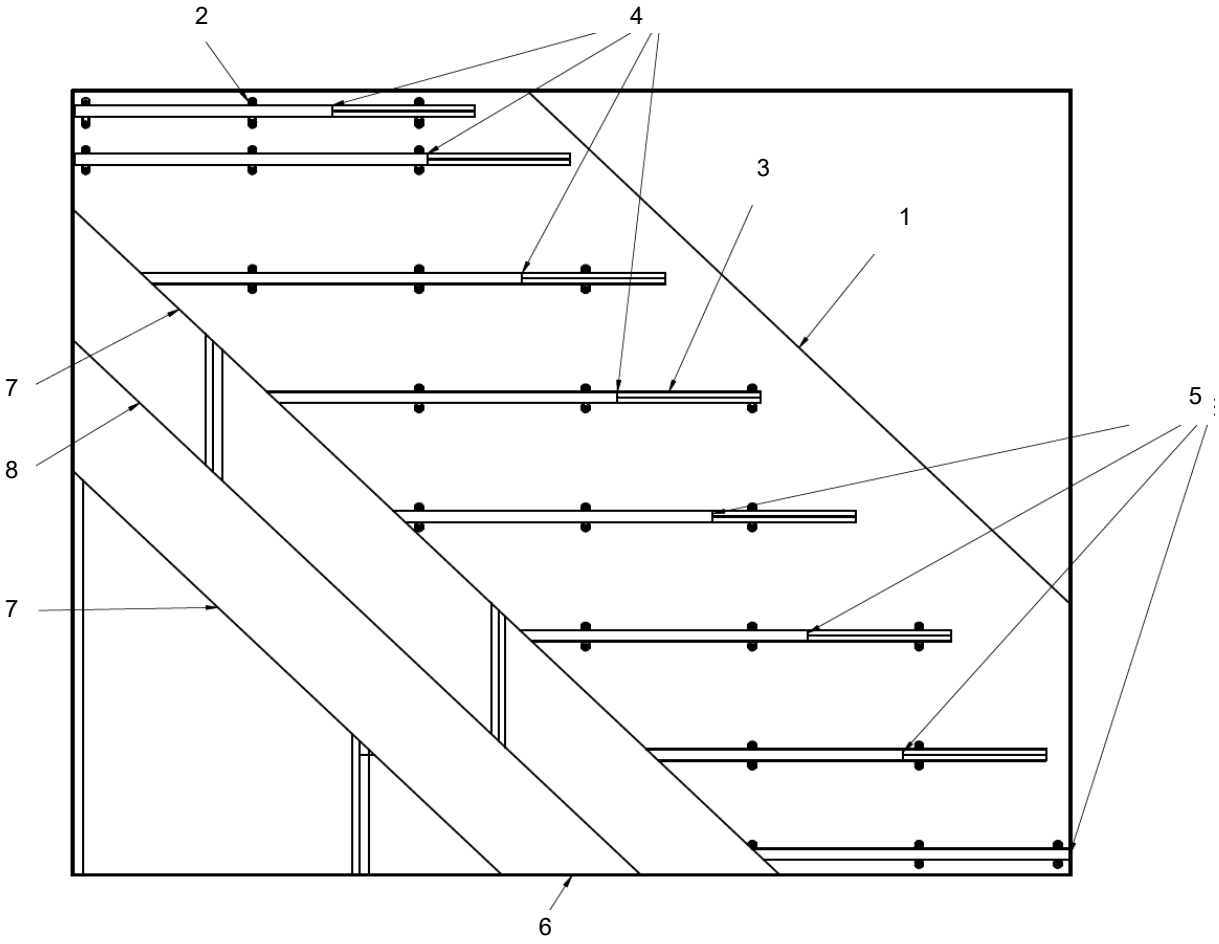
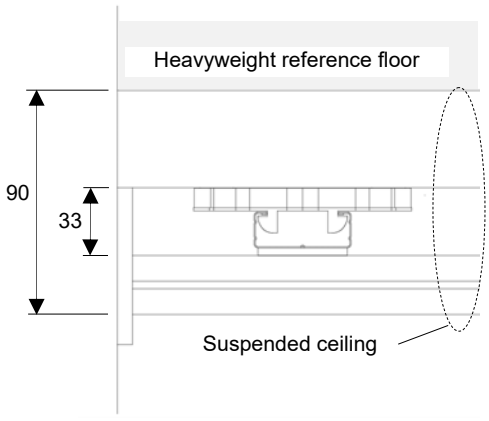
ENAC
ENSAYO
ISO 17025
Nº4 / LE456

1. TEST SPECIMEN DESCRIPTION

The test specimen consists of a suspended ceiling, with the following composition according to the information provided by the client:

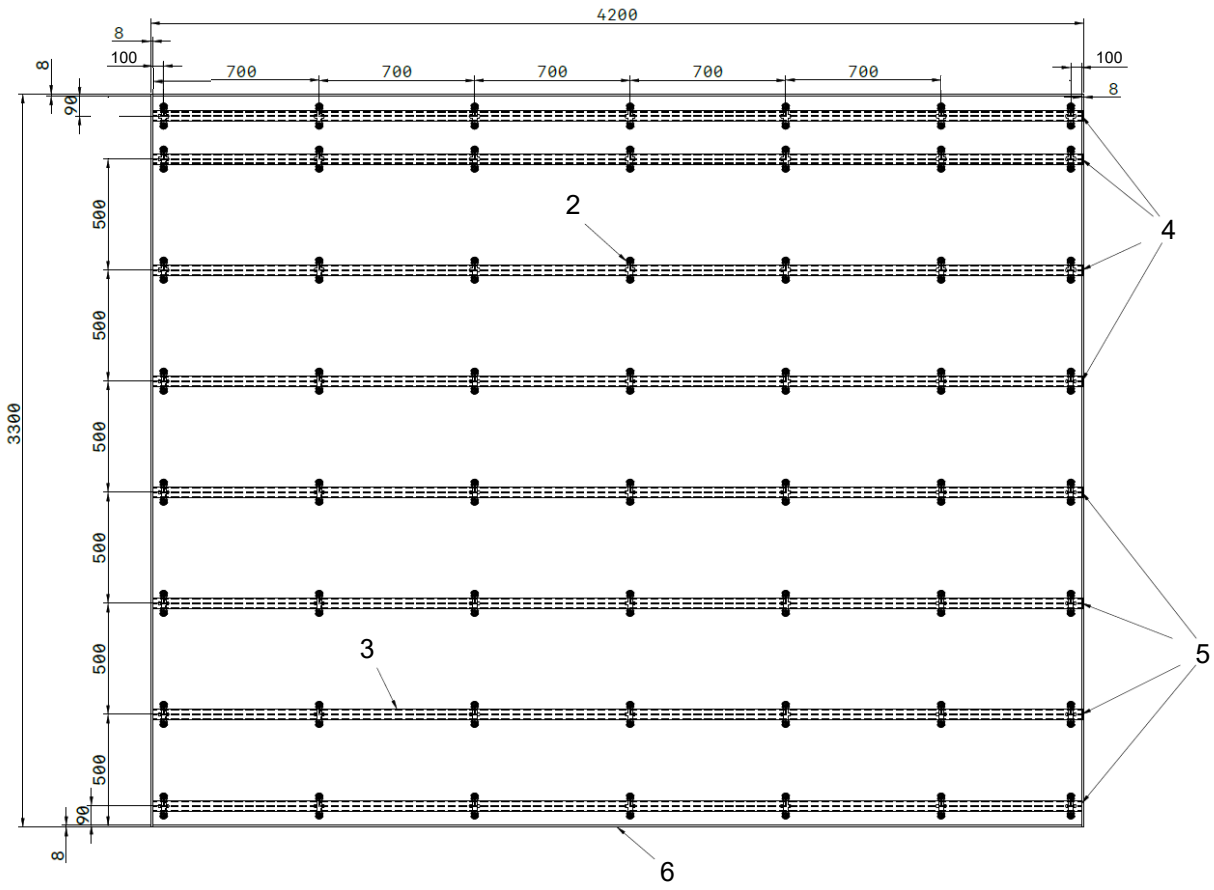


Sketch 1



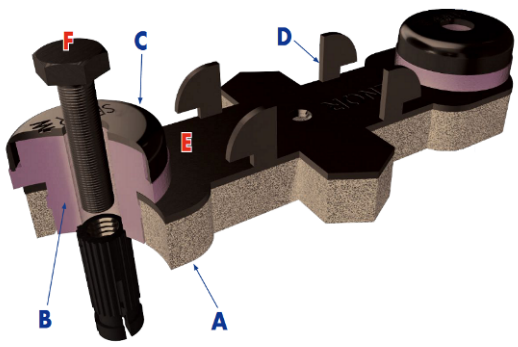
1. DANOFON
2. SE-FTD MINI 47 damper
3. 45 mm profile
4. FONODAN 50 strip
5. SE-MONT-BICAPA-40 strip
6. SE-BEC-8x80 strip
7. 12,5 mm plasterboard
8. M.A.D. 4 membrane

Sketch 2 - Cotes in mm

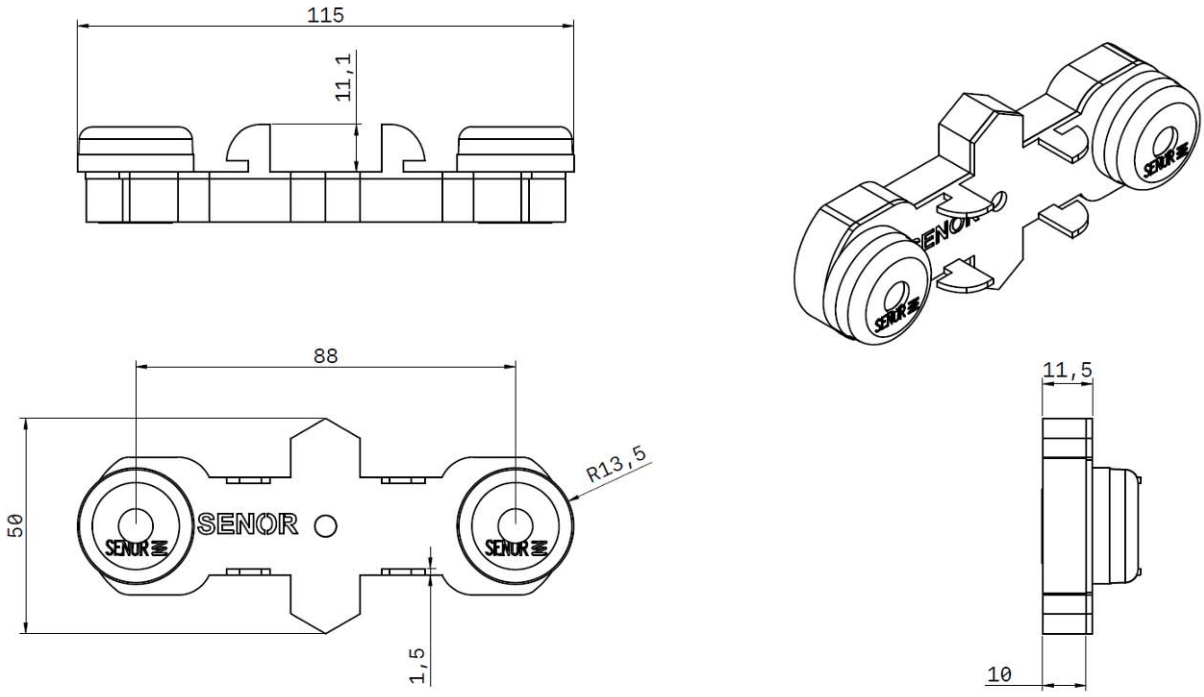


- Dampers on DANOFON, mechanically fixed at 2 points to the floor
- 45 mm profiles fitted in dampers

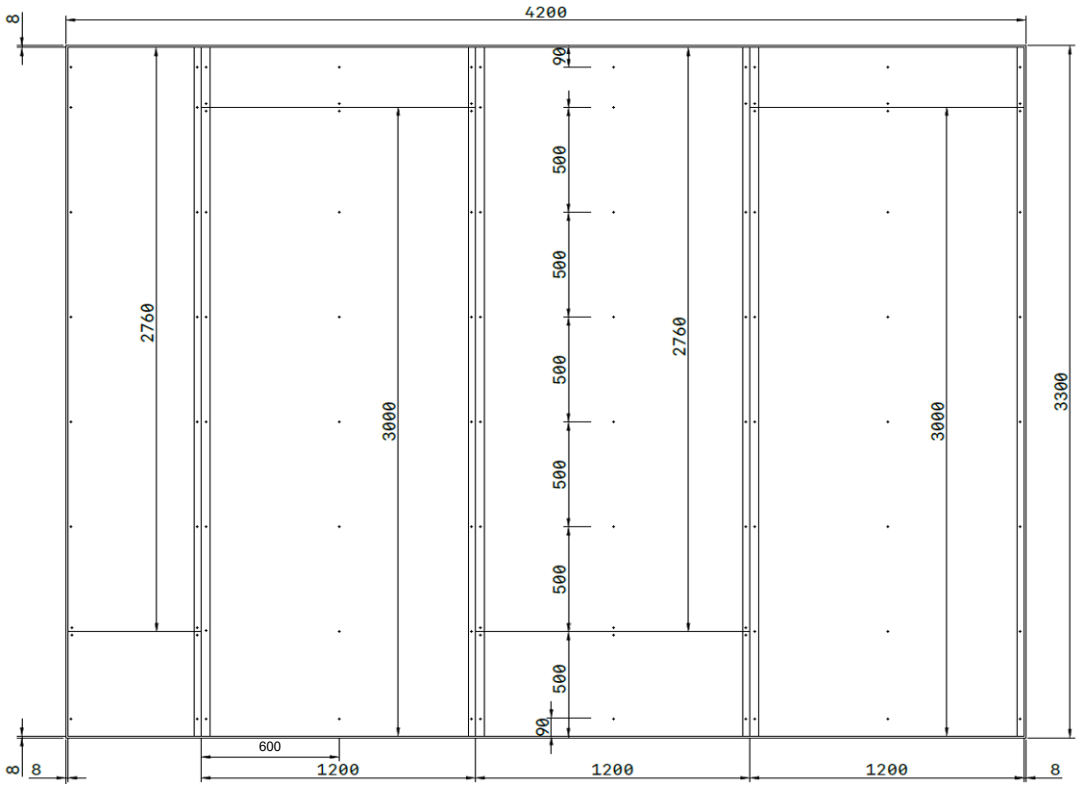
Sketch 3 - Cotes in mm



A. BEC-10: EPDM CR-130 micro cellular strip, 10 mm thick
B. TC4/GPN rubber
C. Steel bowl-shaped leveller
D. CLIP STOP made of high-performance galvanized steel, 1,5 mm thick
E. BASE FTD plate made of high-performance galvanized steel, 1,5 mm thick
F. SAFETY device: steel screw

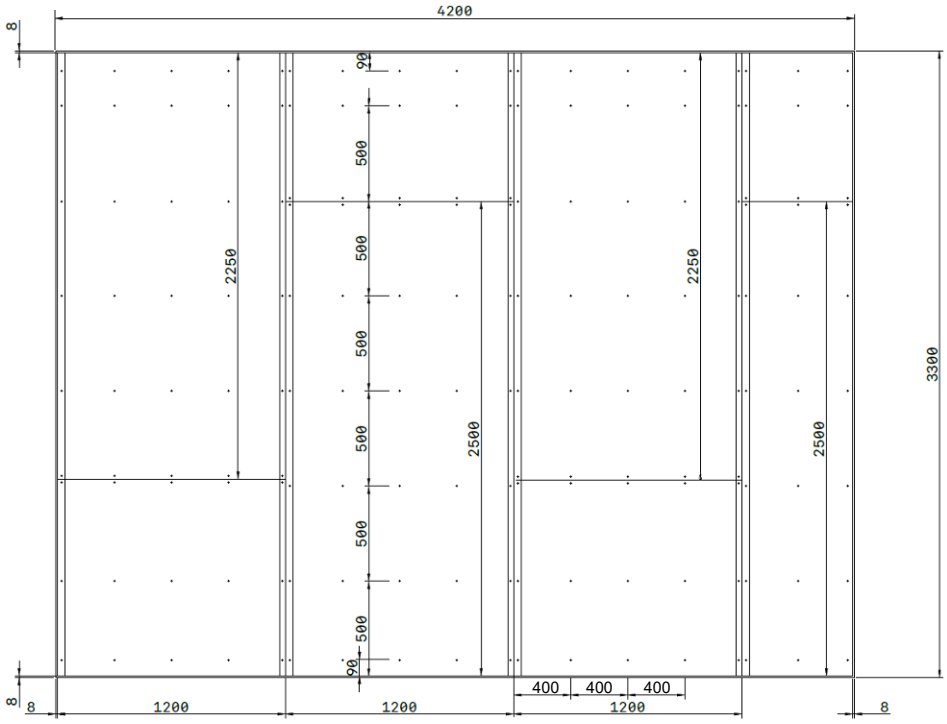


Sketch 4 - Cotes in mm



- Each other butt jointed boards, against SE-BEC strip and mechanically fixed to profiles each ~60 cm.

Sketch 5 (inner layer) - Cotes in mm



- Each other butt jointed boards, against SE-BEC strip and mechanically fixed ~30 cm.
- Sealing of joints between boards and perimeter joint between boards and SE-BEC strip, with joint strip and PLACO PR 1 joint paste.

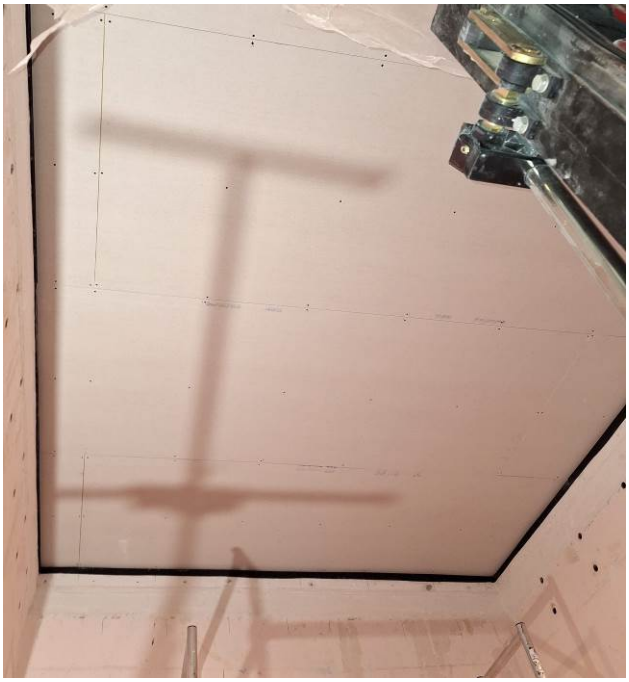
Sketch 6 (outer layer) - Cotes in mm

Description of materials and assembly details:

- SE-BEC-8x80 Acoustic strip (SENOR): EPDM CR-130 Microcellular self-adhesive acoustic strip (8 mm thick x 80 mm wide). Attached to the perimeter.
- DANOFON (DANOSA): Multilayer compound composed of high-density bituminous base sheet and a blanket on each side composed of cotton and recycled textile fibres linked with phenolic resin (28 mm thick and 6,5 kg/m^2). Tongue and groove sections, covering the entire surface of the test specimen.
- SE-FTD MINI 47 damper (SENOR): Acoustic damper. Description in sketch 4. Assembly according to sketch 3.
- 45 mm profile: PLACO F-530 galvanized steel profile, 45x18 mm. Assembly according to sketch 3.
- FONODAN 50 (DANOSA): Double-layer, self-adhesive product (3,9 mm thick and 46 mm wide) composed of one high-density, self-adhesive membrane and one chemically reticulated polyethylene thermically welded to the previous one. Attached to profiles according to sketch 1.
- SE-MONT-BICAPA-40 (SENOR): Self-adhesive desolidarizing strip (5,5 mm thick and 40 mm wide), composed of EPDM 2,5 mm thick + cross-linked polyethylene 3 mm thick. Attached to profiles according to sketch 1.

- 12,5 mm plasterboard: PLACO BA 13 laminated gypsum plasterboard (12,5 mm thick and 8,1 kg/m^2). Assembly according to sketches 5 and 6.

- M.A.D. 4 (DANOSA): Bituminous membrane with mineral fillers, coated on their external faces with a high-density polyethylene film, in roll form (4 mm thick and 6.5 kg/m^2). Each other butt jointed sections and against SE-BEC strip, with staggered sections to those of the laminated gypsum boards.




Photos of assembly of test specimen

Photo of test specimen in the acoustic rooms

Material delivered by: SENOR and DANOSA, each company its referenced material in the test specimen description, and by PLACO, the suspended ceiling material (boards, profiles, screws, tape and compound).

Test arrangement:

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

Test specimen dimensions: 4,2 x 3,3 m (surface 13,86 m^2).

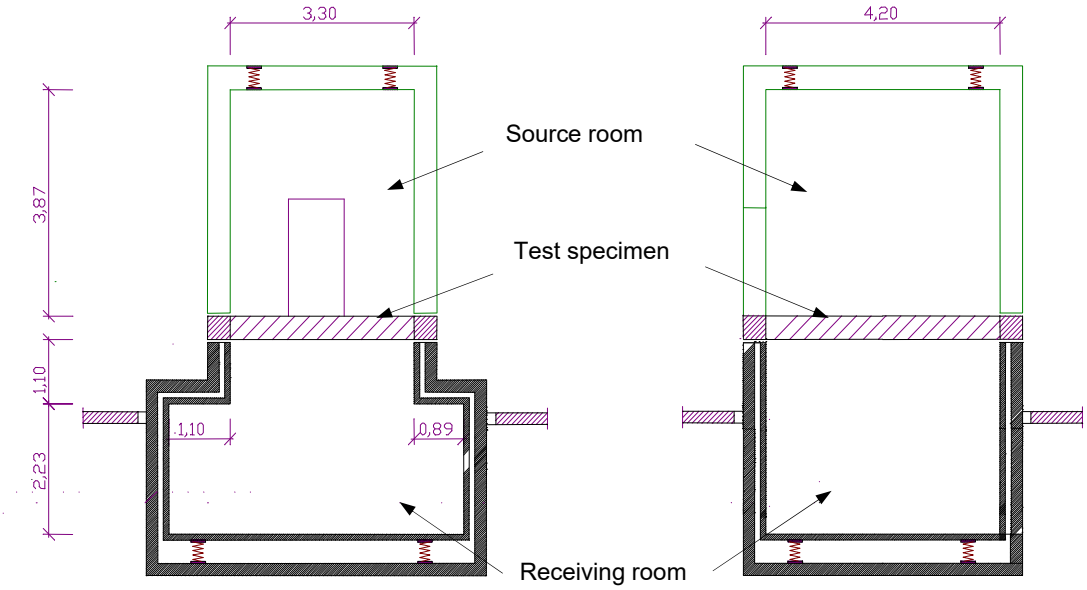
Floor covering Category II, according to EN ISO 10140-1:2021.

Assembly performed by: SENOR

Assembly end date: 21st June 2024

2. TEST FACILITIES

The tests are performed in the vertical transmission rooms, 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. The rooms comply with the requirements of EN ISO 10140-5:2021.



Sketch of vertical transmission acoustic rooms

3. EQUIPMENT AND TEST CONDITIONS

Microphones	Brüel&Kjær 4943; Serial No.3188436	Brüel&Kjær 4943; Serial No. 3188435
Preamplifiers	Brüel&Kjær 2669; Serial No.1948764	Brüel&Kjær 2669; Serial No. 2025844
Sound sources	Brüel&Kjær 4296; Serial No.2071420	BR 112 T/A
Booms	Brüel&Kjær 3923; Serial No.2036584	Brüel&Kjær 3923; Serial No. 2036585
Tapping machine	Brüel&Kjær 3207; Serial No. 02675448	
Analyser	Nor850-MF1; Serial No. 8501186	
Amplifier	LAB 300; Serial No. 970-967	
Equalizer	Sony, SRP-E100; Serial No. 400238	
Calibrator	Brüel&Kjær 4231; Serial No. 2061476	Brüel&Kjær 4231; Serial No. 2061477
Atmospheric conditions meter	Source room Rotronic BL-1D; Nº Serial No. A21050029 Measurement uncertainty: T (± 0,7 ºC), H (±4 %), P (±2 mbar)	Receiving room Rotronic BL-1D; Serial No. A19060062 Measurement uncertainty: T (± 0,7 ºC), H (±4 %), P (±5 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 defined by the sound reduction improvement index, ΔR. For its determination, the airborne sound insulation test of the basic element (heavyweight reference floor specified in EN ISO 10140-5:2021-Annex B) without and with the lining is carried out according to EN ISO 10140-2:2021.

The sound reduction improvement index, ΔR, of a lining placed on a basic element, at one-third octave frequency bands from 100 to 5000 Hz, is obtained according to standard EN ISO 10140-1:2021-Annex G, from the difference between the sound reduction indices of the basic element with and without the lining:

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

R_{with}: Sound reduction index of the basic element with lining

$R_{without}$: Sound reduction index of the basic element without lining

The sound reduction index, R, is obtained 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 equalized white noise 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/cycle during 32 s. of measure, for the heavyweight reference floor and through six fixed positions of the microphone path, for the floor with lining. Background noise in the receiving room is measured according to the same measurement process of sound field in the receiving room.

The equivalent sound absorption area 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. For its determination, the impact sound insulation test of the heavyweight reference floor specified in EN ISO 10140-5:2021-Annex C without and with the floor covering is carried out according to EN ISO 10140-3:2021.

The reduction of impact sound pressure level, ΔL, in decibels, of the floor covering at one-third octave frequency bands from 100 to 5000 Hz is obtained according to standard EN ISO 10140-1:2021-Annex H, 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

L_n: Normalized impact sound pressure level of the heavyweight reference floor with floor covering

Both levels $L_{n,0}$ and L_n, are obtained according to EN ISO 10140-3:2021 using the following formulas:

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

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 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/cycle during 32 s of measure. The impact sound pressure level for the test specimen is obtained as the energy 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 according to the same measurement process of sound field in the receiving room.

The equivalent sound absorption area 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-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 for the test specimen:

- Sound reduction improvement index, ΔR, in decibels, at one-third octave frequency bands from 100 to 5000 Hz, in table and graph.
- Weighted sound reduction improvement index, $R_{w,heavy}$, calculated according to EN ISO 717-1:2020, for the basic element.

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

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

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

- A-weighted improvement of sound reduction indices between 100 and 3150 Hz, $\Delta(R_w+C)_{heavy}$ and $\Delta(R_w+C_{tr})_{heavy}$, calculated in an equivalent way.
- A-weighted improvement of sound reduction indices between 100 and 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 with lining, R_{with}, at one-third octave frequency bands from 100 to 5000 Hz.
- Sound reduction index of the heavyweight reference floor without lining, $R_{without}$, at one-third octave frequency bands from 100 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 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 and 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 ΔR value marked with * means that is greater or equal to the indicated value, due to the measurement limit of the R value marked with * or # at the corresponding frequency. The global index marked with ** means that is greater or equal to the indicated value, due to the limit values in frequencies marked with * or #.

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:

- Reduction of impact sound pressure level, ΔL, at one-third octave frequency bands between 100 and 5000 Hz, in table and graph.

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

- 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 $C_{I,r}$.

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: 01/07/2024

RESULT No.: 110860-861-MRA

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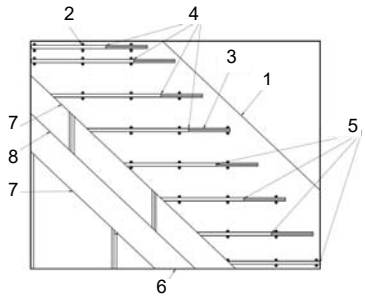
- 45 mm profile
- FONODAN 50 (DANOSA) and SE-MONT-BICAPA-40 (SENOR)
- SE-BEC-8x80 acoustic strip (SENOR)
- 12,5 mm plasterboard
- M.A.D. 4 (DANOSA)
- 12,5 mm plasterboard

Estimated superficial mass: 29 kg/m^2
Test specimen area: 13,86 m^2 (3,3x4,2 m)



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6. SE-BEC-8x80
7. 12,5 mm plasterboard
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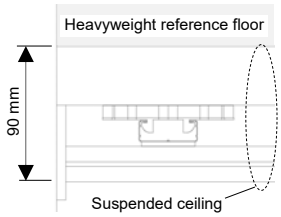


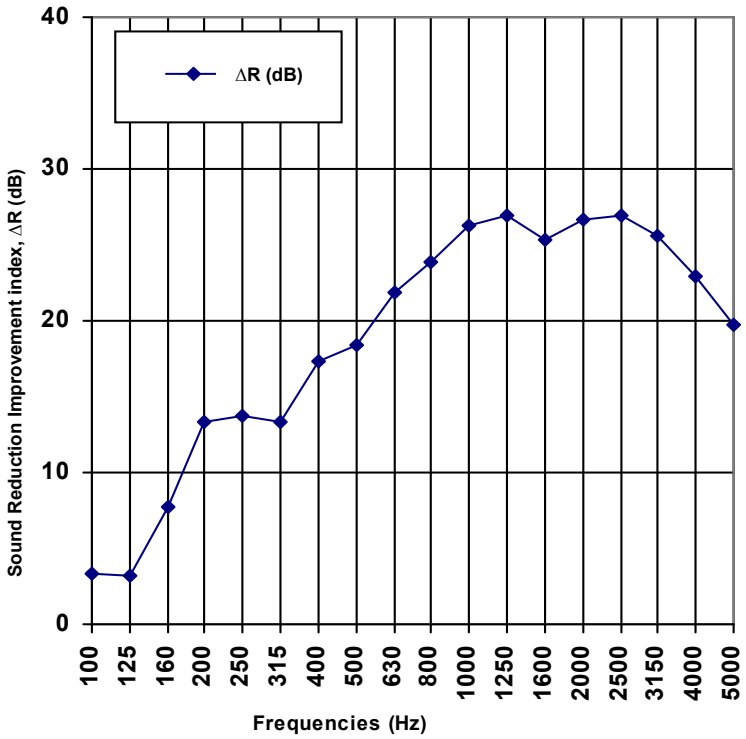
Heavyweight reference floor: Reinforced concrete slab of 150 mm and 375 kg/m^2, tested on 2nd April 2024 ($R_{without}$).

V_{src}: 56,4 m^3; T_{src}: 20,9 ºC; H_{src}: 64 %; P_{src}: 964 mbar

V_{rec}: 63,4 m^3; T_{rec}: 21,5 ºC; H_{rec}: 77 %; P_{rec}: 964 mbar

V: volume; src: source room; rec: receiving room

f (Hz)	R_{with} (dB)	$R_{without}$ (dB)	ΔR (dB)
100	43,7	40,3	3,4
125	46,8	43,6	3,2
160	48,5	40,8	7,7
200	55,6 *	42,2	13,4 *
250	58,4	44,6	13,8
315	61,5	48,2	13,3
400	69,9	52,5	17,4
500	73,3	54,9	18,4
630	77,3	55,4	21,9
800	82,4 *	58,5	23,9 *
1000	86,1 *	59,8	26,3 *
1250	88,7 *	61,8	26,9 *
1600	89,2 *	63,9	25,3 *
2000	93,9 *	67,2	26,7 *
2500	97,1 *	70,2	26,9 *
3150	98,4 #	72,8	25,6 *
4000	97,3 #	74,3 *	23,0 *
5000	96,5 #	76,8 *	19,7 *



$R_w(C; C_{tr})_{with}$: 69(-3;-9) dB **	$R_w(C; C_{tr})_{without}$: 57(-1;-6) dB
$R_{A,with}$: 67,3 dBA **	$R_{A,without}$: 56,5 dBA
$R_{A,tr,with}$: 59,9 dBA **	$R_{A,tr,without}$: 51,5 dBA

Rating according to EN ISO 717-1:2020:

$\Delta R_{w,heavy}$: 13 dB ** / $\Delta(R_w+C)_{heavy}$: 12 dB ** / $\Delta(R_w+C_{tr})_{heavy}$: 11 dB

$\Delta R_A=\Delta(R_w+C_{100-5000})_{heavy}$: 12 dB ** / $\Delta R_{A,tr}=\Delta(R_w+C_{tr,100-5000})_{heavy}$: 11 dB

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

Evaluation based on laboratory measurement results obtained by an engineering method

ENSAYO ISO 17025 Nº4 / LE456

Reduction of impact sound pressure level of a floor covering on heavyweight reference floor according to EN ISO 10140-1:2021-Annex H

Laboratory measurements according to EN ISO 10140-3:2021

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RESULT No.: 110860-861-MRI

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- 12,5 mm plasterboard
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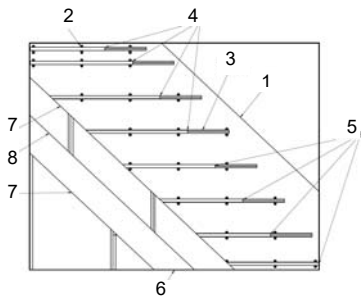
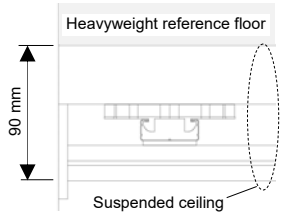
Estimated superficial mass: 29 kg/m^2
Test specimen area: 13,86 m^2 (3,3x4,2 m)



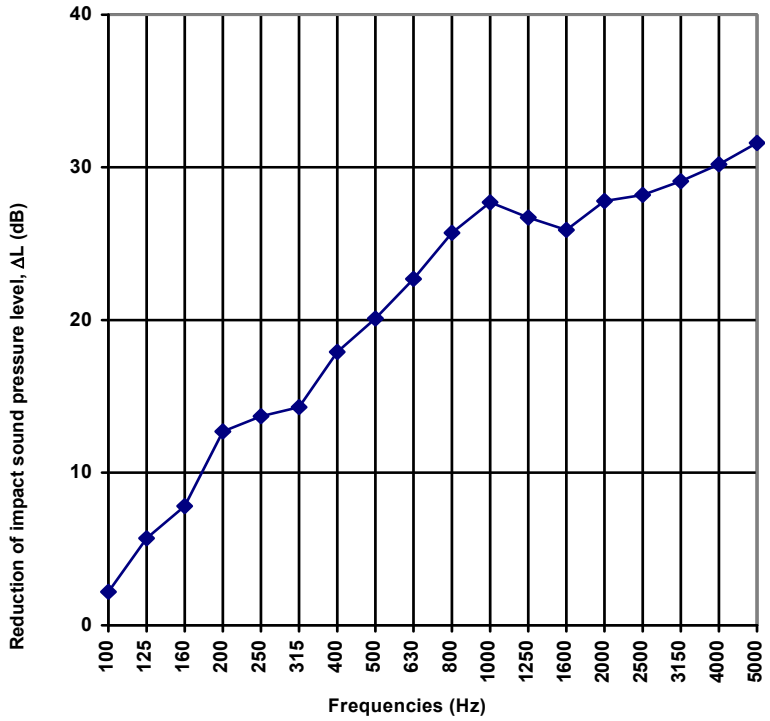
1. DANOFON
2. SE-FTD MINI 47
3. 45 mm profile
4. FONODAN 50
5. SE-MONT-BICAPA-40
6. SE-BEC-8x80
7. 12,5 mm plasterboard
8. MA.D. 4



Heavyweight reference floor: Reinforced concrete slab of 150 mm and 375 kg/m^2, tested on 2nd April 2024 ($L_{n,0}$).

V_{src}: 56,4 m^3; T_{src}: 20,9 ºC; H_{src}: 64 %; P_{src}: 964 mbar
V_{rec}: 63,4 m^3; T_{rec}: 21,5 ºC; H_{rec}: 77 %; P_{rec}: 964 mbar
$T_{upper\ floor\ surface\ centre}$: 20,4 ºC
V: volume; src: source room; rec: receiving room

f (Hz)	$L_{n,0}$ (dB)	L_n (dB)	ΔL (dB)
100	69,1	66,9	2,2
125	64,5	58,8	5,7
160	67,0	59,2	7,8
200	68,7	56,0	12,7
250	68,1	54,4	13,7
315	68,7	54,4	14,3
400	67,7	49,8	17,9
500	68,3	48,2	20,1
630	70,1	47,4	22,7
800	70,5	44,8	25,7
1000	71,9	44,2	27,7
1250	71,7	45,0	26,7
1600	72,1	46,2	25,9
2000	71,5	43,7	27,8
2500	71,1	42,9	28,2
3150	71,1	42,0	29,1
4000	71,0	40,8	30,2
5000	70,1	38,5	31,6



Rating according to EN ISO 717-2:2020: **ΔL_w ($C_{I,\Delta}$): 23 (-10) dB**

$L_{n,0,w}$: 78 dB; $L_{n,w}$: 54 dB; $L_{n,r,w}$: 55 dB; $C_{I,r}$: -1 dB

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

ENSAYO ISO 17025 Nº4 / LE456