TEST REPORT

Report number:	23/32304716
Date of issue:	16th of June, 2023
Client reference:	**EPOLI – ESPUMAS DE POLIETILENO, S.A.** Rua Grova 4745-089 Alvarelhos (Portugal)

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Requested test:	Laboratory measurement of the improvement of impact sound insulation, in accordance with standards UNE-EN ISO 10140-3:2022 and UNE-EN ISO 10140-1:2022 (Annex H).
Test element:	Floor covering composed of polyethylene foam referenced ***PACTPOL FORCE 10 mm HD*** and laminated flooring of 8 mm nominal thickness.
Date of test:	01/06/2023
Test carried out by:	Cristian Torrente

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ENSAYO
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Nº9 / LE766

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This document consists of 14 pages 0 of which are Annexes.

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1.- SCOPE OF THE TEST

Laboratory measurement of the improvement of impact sound insulation, in accordance with the test standards UNE-EN ISO 10140-3:2022 and UNE-EN ISO 10140-1:2022 (Annex H), of a floor covering composed of polyethylene foam referenced ***PACTPOL FORCE 10 mm HD*** and laminated flooring of 8 mm nominal thickness.

2.- MEASUREMENT EQUIPMENT

The equipment used in the test is the following:

- Spectrum analyser id. no.: 170701 (Bruel&Kjaer mod. Pulse LAN-XI)
- Microphone calibrator id. no.: 171067 (Bruel&Kjaer mod. 4231)
- Diffuse field microphones id. no.: 171213 and 171214 (Bruel&Kjaer mod. 4943)
- Rotating microphone boom id. no.: 171142 (Bruel&Kjaer mod. 3923) and 170692 (Ntek mod. MB-01)
- Standard tapping machine id. no.: 103187 (CESVA mod. MI005)
- Omnidirectional sound source id. no.: 170260 (CESVA mod. BP012)
- RT speaker id. no.: 171028 (mod. W5813)
- Noise generator with power amplifier and equalizer id. no.: 171010 (CESVA mod. AP602)
- Thermo-hygrometer and barometer id. no.: 171282 (PCE mod. THB-40)
- Tape measurer id. no.: 103095 (Stanley mod. Powerlock)
- Distance meter id. no.: 170136 (Stanley mod. TLM130)
- Set of weights id. no.: 170564 (9 weights are used)

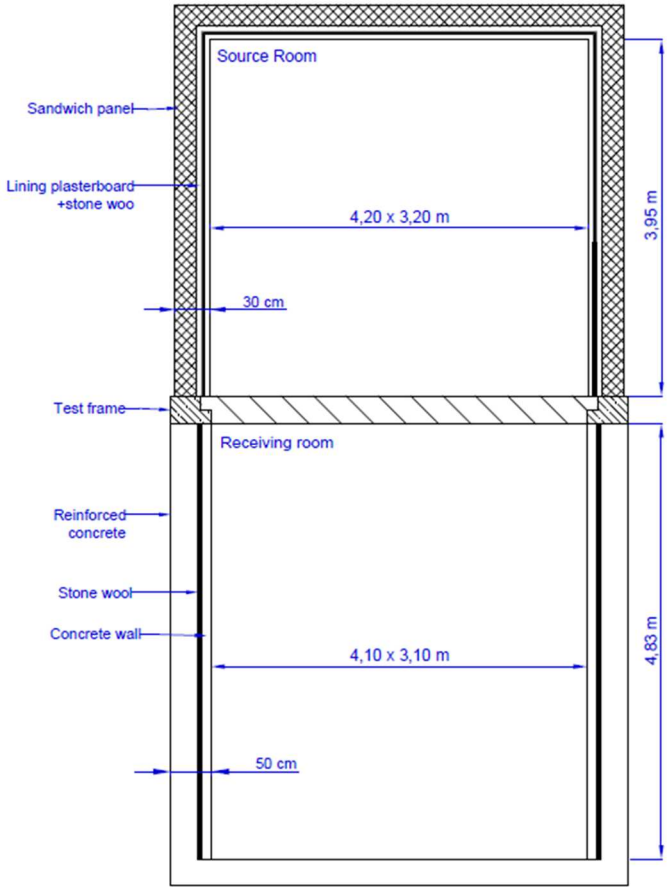
3.- TEST PROCEDURE AND EVALUATION

3.1. TEST METHOD

The test is carried out in accordance with the standards UNE-EN ISO 10140-3:2022 "Measurement of impact sound insulation" together with UNE-EN ISO 10140-1:2022 (Annex H) "Floor coverings. Improvement of impact sound insulation", which are part of the set of standards UNE-EN ISO 10140 "Laboratory measurement of sound insulation of building elements".

The test procedure consists on measuring the impact sound insulation of a basic construction (reference floor) with and without the floor covering to be tested. Both measurements are carried out according to the standard UNE-EN ISO 10140-3:2022.

Two vertically adjacent rooms are used; the upper being designated the 'source room' and the lower the 'receiving room'. The test element is installed in the opening between those rooms. The test procedure is based on measuring for every frequency band within the range of study, customarily from 100 Hz to 5000 Hz, the sound pressure level in the 'receiving room' when exciting the upper floor with a standardized tapping machine placed in at least four different positions. The equivalent absorption area in the receiving room is calculated from the reverberation time measurements.



Schematic drawing of the test rooms

Sound pressure level and reverberation time measurements are carried out according to the standard UNE-EN ISO 10140-4:2022.

The background noise level shall be at least 6 dB (and preferably more than 15 dB) below the level of signal and background noise combined at each frequency band. If the measured sound pressure level does not fulfil this condition, the corrections indicated in section 4.3 of the standard UNE-EN ISO 10140-4:2022 shall be applied.

At each frequency band, the **normalized sound pressure level**, $\mathbf{L_n}$, is calculated increasing the impact sound pressure level, L_i, by a correction term which depends on the reverberation time and the receiving room volume:

$$L_n = L_i + 10\ Log\ (\frac{A}{A_0})\ \text{[dB]}$$

where:

- L_i is the impact sound pressure level, corrected by the background noise if necessary, at each frequency band;
- A_0 is the reference equivalent absorption area, 10 m²;
- A is the measured equivalent absorption area of the receiving room, defined in the UNE-EN ISO 10140-4:2022, and calculated by:

$$A = \frac{0.16V}{T}\ [m^2]$$

where:

- V is the receiving room volume, en m^3;
- T is the reverberation time in the receiving room, in seconds. It is defined as the time required for the sound pressure level in a room to decrease by 60 dB after the sound source has stopped.

When the difference between the airborne sound pressure level and impact sound pressure level is less than 10 dB, the airborne sound transmission from the source room to the receiving room cannot be disregarded. In these cases, the correction for airborne noise as specified by the UNE-EN ISO 10140-3:2022 should be applied to L_n calculation.

3.2. IMPROVEMENT OF IMPACT SOUND INSULATION

The standard UNE-EN ISO 10140-1:2022 "Application rules for specific products" specifies, in Annex H "Floor coverings. Improvement of impact sound insulation" the procedure to measure the improvement of impact sound insulation of floor coverings intended to improve the impact sound insulation of floors.

The quantity determined is the **improvement of impact sound insulation**, **ΔL**, in decibels, defined as the reduction in normalized impact sound pressure level resulting from the installation of the test floor covering on the reference floor:

$$\Delta L = L_{n0} - L_n\ \text{[dB]}$$

where:

- L_{n0} is the normalized impact sound pressure level of the reference floor without the floor covering;
- L_n is the normalized impact sound pressure level of the reference floor with the floor covering.

The standard reference floors are defined in the standard UNE EN-ISO 10140-5:2022 Annex C; one heavyweight reference floor and three lightweight reference floors. Commonly the heavyweight reference floor is the floor used, which consist of a reinforced concrete slab of thickness 120^{+40}_{-20} mm, preferably 140 mm for the construction of new laboratories. It should be homogeneous and shall be of uniform thickness.

3.3. PROCEDURE FOR EVALUATING SINGLE-NUMBER QUANTITIES FOR IMPACT SOUND INSULATION RATING

The method of measurement gives values for the impact sound insulation which are frequency dependent. The standard UNE-EN ISO 717-2:2021 normalizes a method whereby the frequency-dependent values of impact sound insulation can be converted into a single number characterizing the acoustical performance.

From the curve of impact sound it is possible to obtain the global weighted value comparing that curve with the reference spectrum (given in table 3.1) defined between 100 and 3150 Hz:

freq. (Hz)	100	125	160	200	250	315
Ref.	62	62	62	62	62	62
freq. (Hz)	400	500	630	800	1000	1250
Ref.	61	60	59	58	57	54
freq. (Hz)	1600	2000	2500	3150	4000	5000
Ref.	51	48	45	42	- -	- -

Table 3.1: Reference values for impact sound for every frequency band

The global weighted value is the value, in decibels, of the reference curve at 500 Hz after shifting it in accordance with the following procedure.

To evaluate the results of a measurement (L_n, for example), the reference spectrum is shifted in increments of 1 dB towards the measured curve until the sum of unfavourable deviations is as large

as possible but not more than 32,0 dB. An unfavourable deviation at a particular frequency occurs when the results of measurements exceed the reference value for that frequency band.

By the appliance of this evaluation to the normalized impact sound pressure level, L_n, the **weighted normalized impact sound pressure level**, **L_{nw}**, is obtained.

Single-number rating determination in accordance with UNE-EN ISO 717-2:2021 has been based on a result (normalized sound pressure level, L_n) obtained by a laboratory measurement

3.4. PROCEDURE FOR EVALUATING THE WEIGHTED REDUCTION IN IMPACT SOUND PRESSURE LEVEL, ΔL_w

To calculate the **weighted reduction in impact sound pressure level**, **ΔL_w**, it is necessary to relate the measured ΔL levels with a reference floor. The reference floor is defined by the values for the normalized impact sound pressure level, $L_{n,r,0}$, given in table 3.2:

freq. (Hz)	100	125	160	200	250	315
Ref.	67	67,5	68	68,5	69	69,5
freq. (Hz)	400	500	630	800	1000	1250
Ref.	70	70,5	71	71,5	72	72
freq. (Hz)	1600	2000	2500	3150	4000	5000
Ref.	72	72	72	72	- -	- -

Table 3.2: One-third octave band values of the reference curve

The weighted normalized impact sound pressure level of the reference floor, $L_{n,r,0,w}$, is 78 dB.

The weighted reduction of impact sound pressure level, ΔL_w, is calculated according to the following equations:

$$L_{n,r} = L_{n,r,0} - \Delta L$$
$$\Delta L_W = L_{n,r,0,W} - L_{n,r,w} = 78\ dB - L_{n,r,w} \quad [dB]$$

where:

- $L_{n,r}$ is the calculated normalized impact sound pressure level of the reference floor with the floor covering under test;
- $L_{n,r,0}$ is the defined normalized impact sound pressure level of the reference floor (see Table 3.2);

- ΔL is the reduction in impact sound pressure level measured in accordance with the standard UNE-EN ISO 10140-1:2022;
- $L_{n,r,w}$ is the calculated weighted normalized impact sound pressure level of the reference floor with the floor covering under test;
- $L_{n,r,0,w}$ is obtained in accordance with section 4.3.1 of the standard UNE-EN ISO 717-2:2021 (see section 3.3).

The reduction in impact sound pressure level measured on a concrete floor slab as defined in the Annex H of the standard UNE-EN ISO 10140-1:2022 and the single-number quantity ΔL_w may only be used in connection with similar types of massive floors (concrete, hollow concrete, hollow bricks and similar); it is not appropriate for use on other types of construction.

3.5. CALCULATION OF THE SPECTRUM ADAPTATION TERMS

The rating by $L_{n,w}$ has been shown to be quite adequate in characterizing impact noise like walking for wooden floors and concrete floors with effective coverings such as carpets or floating floors. However, it insufficiently takes into account level peaks at single (low) frequencies, for instance with timber joist floors, or the behaviour of bare concrete floors in this respect. There is clear evidence that the unweighted impact level of the tapping machine is more representative of the A-weighted impact levels as caused by walking for all types of floor, while this rating is also more restrictive to single noise peaks.

Therefore an adaptation term C_I is introduced to take this effect into account, given as a separate number which cannot be confused with the value for $L_{n,w}$. This term is so defined that for massive floors with effective coverings its value is about zero, while for timber joist floors with dominating low frequency peaks it will be slightly positive. For concrete floors without cover or with less effective covering, it will range from -15 to 0 dB.

If these effects are to be taken into account in requirements, these could be written as the sum of $L_{n,w}$ and C_I.

The results of a measurement of L_n in one-third-octave bands in the frequency range 100 Hz to 2500 Hz are added up on an energetic basis resulting the $L_{n,sum}$. The spectrum adaptation term C_I is calculated from the following equation:

$$C_I = L_{n,sum} - 15 - L_{n,w} \quad \text{[dB]}$$

The spectrum adaptation term is calculated with decimal precision and rounded to an integer afterwards.

A spectrum adaptation term for flat response for the impact sound reduction may be determined and stated. This spectrum adaptation term $C_{I\Delta}$ is calculated from:

$$C_{I\Delta} = C_{I,r,0} - C_{I,r} \quad [\text{dB}]$$

where:

- $C_{I,r}$ is the spectrum adaptation term for the reference floor with the floor covering under test;
- $C_{I,r,0}$ is the spectrum adaptation term for the reference floor with $L_{n,r,0}$ ($C_{I,r,0}$ = - 11 dB).

3.6. UNCERTAINTY OF RESULTS

The uncertainty associated to the test has been calculated and is available to the petitioner. The expanded uncertainty has been calculated as the typical measurement uncertainty multiplied by a coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

4.- REFERENCE FLOOR AND STANDARD TAPPING MACHINE DESCRIPTIONS

The basic element is a heavyweight reference floor in accordance with the requirements in the Annex C of the standard UNE-EN ISO 10140-5:2022. It is a reinforced concrete slab of thickness 140 mm, homogeneous and of uniform thickness.

The tapping machine is a standard tapping machine that fulfils the requirements of the standard UNE-EN ISO 10140-5:2022 Annex E.

5.- TEST ELEMENT DESCRIPTION

The main characteristics of the test element, provided by the test petitioner, are listed below. The references/models and the information indicated with *(*)* is provided by the test petitioner. LGAI Technological Center, S.A. is not responsible for the documentation and/or information provided for the petitioner and such information is not covered by accreditation.

Applus test specimen no.	15641
Type of test specimen	Floor covering
Manufacturer	Polyethylene foam: EPOLI – ESPUMAS DE POLIETILENO, S.A.
Model / Reference	High-density synthetic membrane: ***PACTPOL FORCE 10 mm HD***
Supplied by	Polyethylene foam: EPOLI – ESPUMAS DE POLIETILENO, S.A.
Date received	Polyethylene foam: 22/05/2023
Area of test element	10,90 m^2 – 3783 x 2880 mm
Test opening	12,71 m^2 – 4,10 x 3,10 m
Test element thickness	≈158 mm (reference floor: 140 mm ;floor covering: ≈18 mm)
Mass per unit area, *m* (estimated)	≈357 kg/m^2 (reference floor: ≈350 kg/m^2; floor covering: ≈7 kg/m^2)
Type of mounting	In the opening of a concrete frame (test frame)
Composition	- Reference floor: Heavyweight reference floor, heavyweight standard floor in accordance with the Annex C of standard UNE-EN ISO 10140-5:2022. Reinforced concrete slab of thickness 140 mm - Floor covering of 3783 x 2880 mm composed of: o Polyethylene foam referenced ***PACTPOL FORCE 10mm HD*** of 10 ± 1 mm nominal thickness and 40 ± 5 kg/m^3 nominal density. *(*)* o Laminated flooring of 8 mm nominal thickness.
Test arrangement	In accordance with the specifications in Section 6 of UNE-EN-ISO 10140-3:2022 and Annex H of UNE-EN-ISO 10140-1:2022
Type of floor covering	Category II, according to Annex H of UNE-EN ISO 10140-1:2022
Test element assembling (carried out by/date)	Applus Laboratories – LGAI Technological Center / 31/05/2023
Constructive details	See figures 1 and 2

In order to determinate the improvement of impact sound insulation provided by the floor covering two measurements are carried out: the measurement of the standard reference floor without the floor covering (19/01/2023) and the measurement of the standard reference floor with the floor covering (01/06/2023).



Images 1 and 2 Details of *PACTPOL FORCE 10 mm HD*



Images 3 and 4 Details of laminated flooring

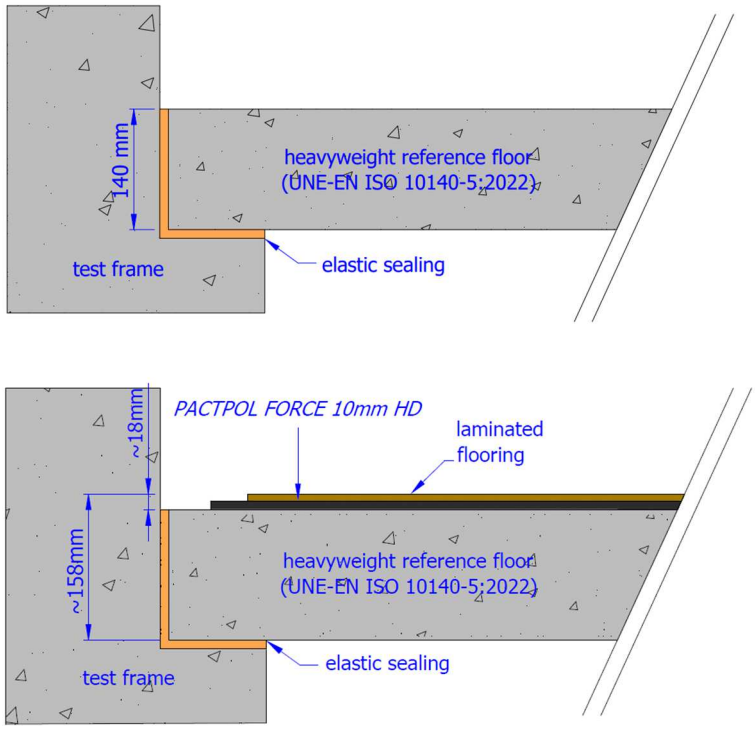


Images 5 to 8 Installation of the floor covering



Images 9 and 10 Test specimen installed and ready for the test (without and with load, respectively)

The following figures show the sections of the tested constructions.



Figures 1 and 2 Reference floor and reference floor with the floor covering

6.- TEST CONDITIONS

6.1. STANDARD REFERENCE FLOOR (heavyweight reference floor in accordance with UNE-EN ISO 10140-5:2022 Annex C)

	Source Room	Receiving Room
Room volumes	52,9 m^3	62,9 m^3
Climatic conditions	Temperature: 14,6 ±0,4 ºC	Temperature: 14,5 ±0,4 ºC
	Humidity: 50,8 ±4,4 %	Humidity: 63,2 ±4,4 %
	Static pressure: 998,0 ±1,3 hPa	

6.2. STANDARD REFERENCE FLOOR + FLOOR COVERING

	Source Room Note 1	Receiving Room
Room volumes	52,7 m^3	62,9 m^3
Climatic conditions	Temperature: 20,3 ±0,4 ºC	Temperature: 19,0 ±0,4 ºC
	Humidity: 67,3 ±4,4 %	Humidity: 68,8 ±4,4 %
	Static pressure: 998,8 ±1,3 hPa	

Note 1: The floor covering (test element) is located into the source room

7.- RESULTS

The test results of the tested element are showed below: the floor covering installed on the standard reference floor, without load (section 7.1.) and under a uniformly distributed load of 20 kg/m^2 to 25 kg/m^2 (section 7.2.).

NOTE

The airborne sound pressure level and impact sound pressure level differ by less than 10 dB (the condition $L_i - (L_{TS} - D) \geq 10$ dB is not confirmed in all frequency bands), so that the transmission of airborne sound from the source room to the receiving room cannot be neglected. For this reason, the airborne sound correction specified by section 5.4 of UNE-EN ISO 10140-3:2022 has been applied to the calculation of L_n.

7.1. FLOOR COVERING WITHOUT LOAD

Reduction of impact sound pressure level in accordance with the Standard ISO 10140 (all parts)

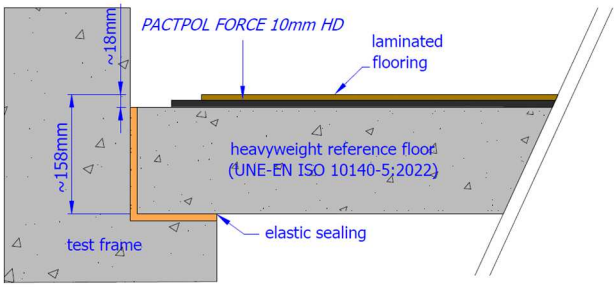
Client: EPOLI – ESPUMAS DE POLIETILENO, S.A.

Test element:
Floor covering composed of polyethylene foam referenced ***PACTPOL FORCE 10 mm HD*** and laminated flooring of 8 mm nominal thickness, installed on a heavyweight reference floor (standard reference floor in accordance with UNE-EN ISO 10140-5:2022 Annex C).

Mass per unit area, *m*: ≈357 kg/m²
(≈7 kg/m² floor covering)

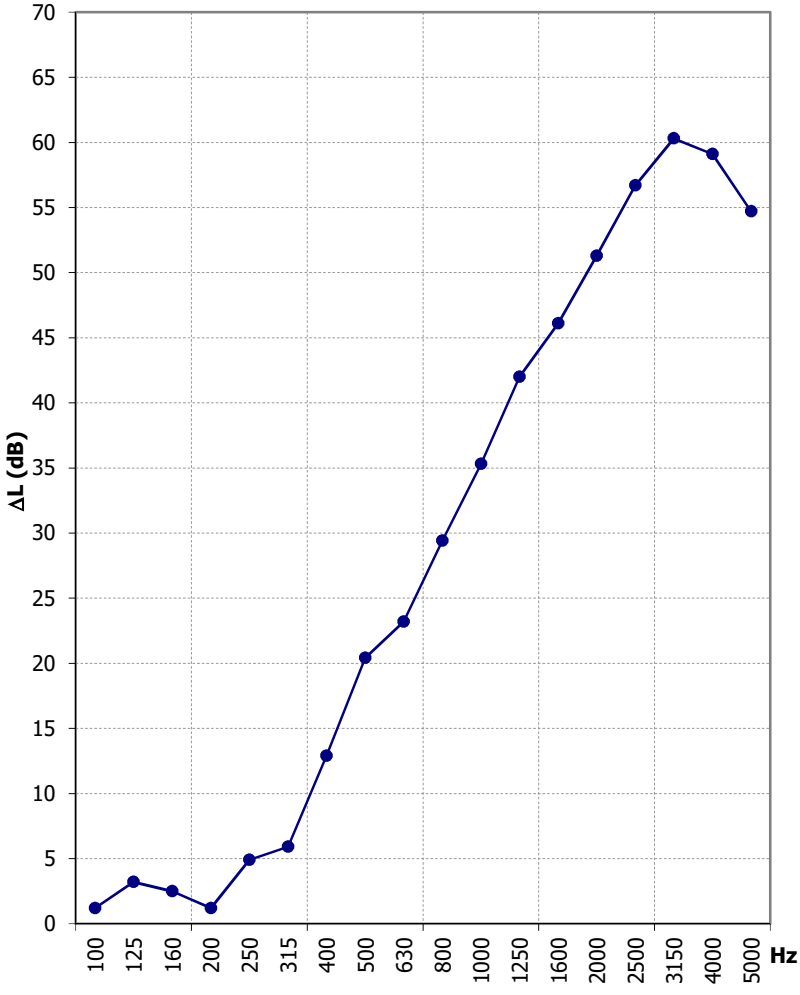
Area of test element: 10,90 m² – 3783 x 2880 mm

Date of test: 01/06/2023 (reference floor: 19/01/2023)



Frequency (Hz)	$L_{n,0}$ (dB)	ΔL (dB)
100	54,2	1,2
125	60,9	3,2
160	68,6	2,5
200	68,0	1,2
250	73,8	4,9
315	71,7	5,9
400	74,2	12,9
500	73,0	20,4
630	73,6	23,2
800	73,2	29,4
1000	73,9	35,3
1250	74,4	42,0
1600	74,3	46,1
2000	74,8	51,3
2500	74,6	56,7
3150	74,1	60,3
4000	73,1	59,1
5000	70,8	54,7

Reduction of transmitted impact sound pressure level, ΔL



UNE- EN ISO 717-2:2021	$L_{n,0,w}$ =	81 dB	$L_{n,w}$ =	58 dB	$L_{n,r,w}$ =	58 dB	**ΔL_w = 20 dB**
	$C_{I,0}$ =	-11 dB	C_I =	1 dB	$C_{I,r}$ =	0 dB	$C_{I\Delta}$ = -11 dB

The results reported in this document relate only to the sample, product or item delivered to LGAI Technological Center the appointed day having been tested under the conditions established in this document.

7.2. FLOOR COVERING WITH LOAD

Reduction of impact sound pressure level in accordance with the Standard ISO 10140 (all parts)

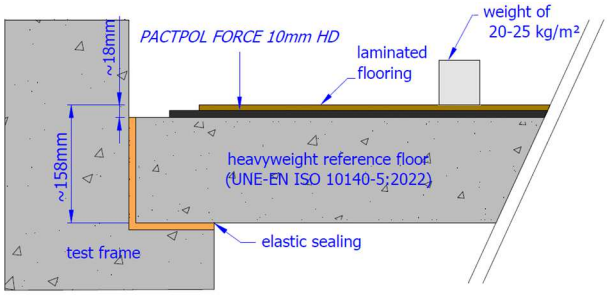
Client: EPOLI – ESPUMAS DE POLIETILENO, S.A.

Test element:
Floor covering composed of polyethylene foam referenced ***PACTPOL FORCE 10 mm HD*** and laminated flooring of 8 mm nominal thickness, installed on a heavyweight reference floor (standard reference floor in accordance with UNE-EN ISO 10140-5:2022 Annex C).
Measurement with load of 20-25 kg/m².

Mass per unit area, *m*: ≈357 kg/m²
(≈7 kg/m² floor covering)

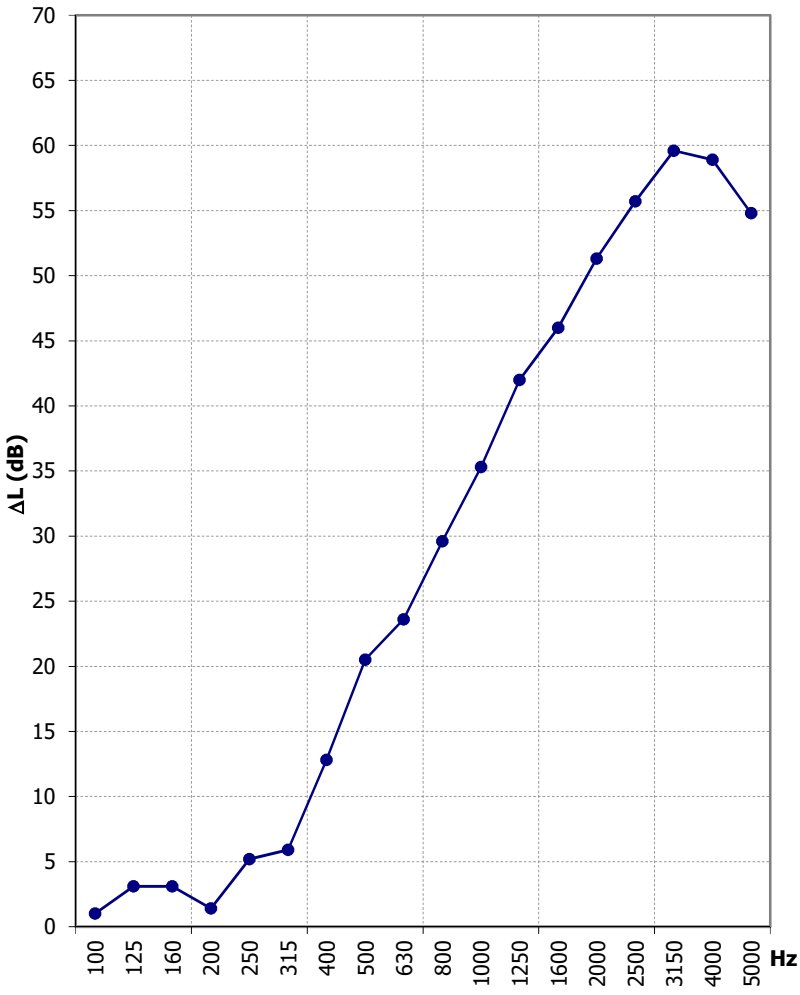
Area of test element: 10,90 m² – 3783 x 2880 mm

Date of test: 01/06/2023 (reference floor: 19/01/2023)



Frequency (Hz)	$L_{n,0}$ (dB)	ΔL (dB)
100	54,2	1,0
125	60,9	3,1
160	68,6	3,1
200	68,0	1,4
250	73,8	5,2
315	71,7	5,9
400	74,2	12,8
500	73,0	20,5
630	73,6	23,6
800	73,2	29,6
1000	73,9	35,3
1250	74,4	42,0
1600	74,3	46,0
2000	74,8	51,3
2500	74,6	55,7
3150	74,1	59,6
4000	73,1	58,9
5000	70,8	54,8

Reduction of transmitted impact sound pressure level, ΔL



UNE- EN ISO 717-2:2021	$L_{n,0,w}$ =	81 dB	$L_{n,w}$ =	58 dB	$L_{n,r,w}$ =	58 dB	**ΔL_w = 20 dB**
	$C_{I,0}$ =	-11 dB	C_I =	0 dB	$C_{I,r}$ =	0 dB	$C_{I\Delta}$ = -11 dB

The results reported in this document relate only to the sample, product or item delivered to LGAI Technological Center the appointed day having been tested under the conditions established in this document.

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Relatório de Testes e Ensaios

Cliente: EPOLI - Espumas de Polietileno, S.A.

Proposta comercial: PSO067.2023

Relatório: PSR067.2023

Data: 14/04/2023

1. Objetivo

Determinação das propriedades em compressão da amostra de espuma disponibilizada pelo cliente, a 31 de março de 2023, sob a forma de provetes (Figura 1). De acordo com informação fornecida pelo cliente, trata-se de uma amostra de espuma em polietileno com uma densidade de 40 kg/m^3.



Figura 1 – Provetes de espuma disponibilizados pelo cliente para ensaios de compressão (provetes com as seguintes dimensões: 50 mm x 50 mm x 10 mm)

2. Trabalho experimental realizado

As propriedades em compressão da amostra de espuma foram determinadas com base da norma ISO 3386-1, utilizando uma máquina universal de ensaios mecânicos Shimadzu AG-X, com uma célula de carga de 50 kN, e pratos paralelos para compressão com 100 mm diâmetro. Os ensaios foram realizados à temperatura de (23±2) °C e com (50±5) % de humidade relativa.

Os resultados apresentados referem-se exclusivamente aos itens ensaiados. É expressamente proibida a reprodução parcial deste relatório sem expressa autorização do PIEP.

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Foram ensaiados sete provetes, com uma área de cerca de 50 mm x 50 mm e 10 mm de espessura, preparados e disponibilizados pelo cliente (Figura 1). Os provetes foram comprimidos até 70 % da sua espessura inicial, à taxa de 100 mm/min e descomprimidos, à mesma taxa de deformação, até ao valor da sua espessura inicial. Repetiu-se o ciclo de compressão e descompressão mais três vezes consecutivas. Registaram-se as curvas de variação da tensão em função da deformação nos quatro ciclos e, a partir da curva registada no quarto ciclo, determinou-se o valor da tensão de compressão a 10, 25, 40, 50 e 65 % de deformação (valores CC_{10}, CC_{25}, CC_{40} (=CV_{40}), CC_{50} e CC_{65}, respetivamente).

A tensão de compressão à deformação xx (CC_{xx}) foi calculada através da seguinte equação:

$$CC_{xx} = 1000 \times \frac{F_{xx}}{A} \quad (1)$$

onde F_{xx} é o valor de força, em Newton, registada na deformação xx no quarto ciclo de carregamento e A a área da superfície sujeita à compressão (≈ 50x50 mm^2).

3. Resultados

As curvas tensão *versus* deformação registadas nos ensaios de compressão efetuados aos sete provetes da amostra de espuma em questão são apresentadas na Figura 2. Na Tabela 1, são indicados os valores de tensão de compressão a 10, 25, 40, 50 e 65 % de deformação (CC_{10}, CC_{25}, CC_{40} (=CV_{40}), CC_{50} e CC_{65}, respetivamente), determinados a partir das curvas correspondentes ao quarto ciclo de carregamento.

Tabela 1 – Valores de tensão de compressão determinados a 10, 25, 40, 50 e 65 % de deformação da amostra de espuma, com base na norma ISO 3386-1 (valores expressos em kPa)

Provete	CC_{10}	CC_{25}	CC_{40} (CV_{40})	CC_{50}	CC_{65}
1	1,2	20,9	49,0	77,3	154,0
2	0,7	20,0	47,6	75,0	147,7
3	1,5	21,0	48,9	77,2	154,8
4	1,8	21,9	50,3	79,1	158,0
5	2,2	23,4	54,4	87,0	183,2
6	1,4	19,9	46,5	72,6	141,4
7	2,9	24,7	56,0	88,3	180,7
Valor médio	**1,7**	**21,7**	**50,4**	**79,5**	**160,0**
Desvio padrão	0,7	1,8	3,5	5,9	16,0

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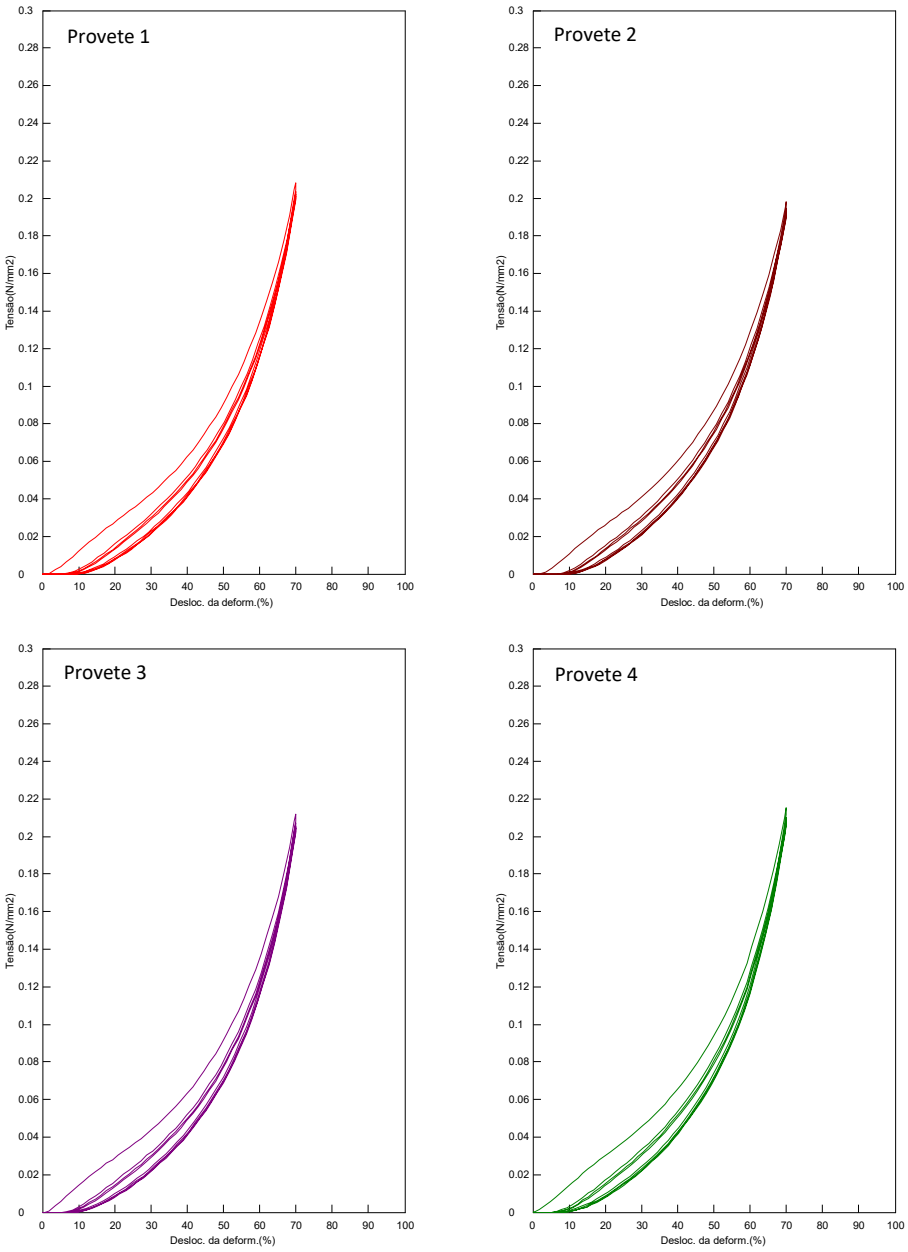
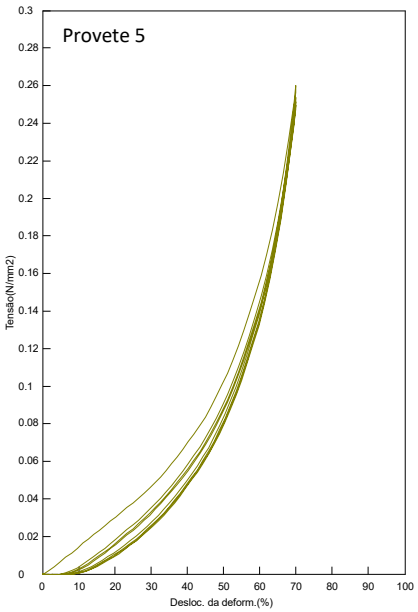
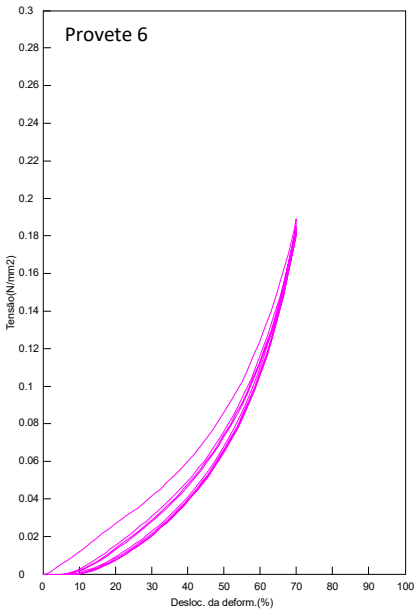


Figura 2 - Curvas tensão *versus* deformação registadas nos ensaios de compressão efetuados à espuma disponibilizada para ensaio (continua página seguinte)

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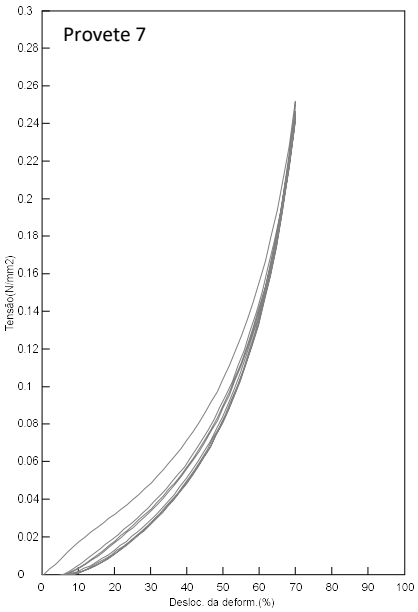


Figura 2 (continuação) - Curvas tensão *versus* deformação registadas nos ensaios de compressão efetuados à espuma disponibilizada para ensaio

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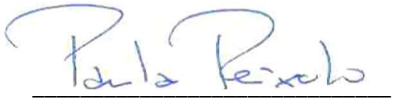
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