Laboratory Measurement of Impact Sound Insulation of Floor Coverings on a Heavyweight Concrete Slab Floor

Report INR183/R1
April 2013

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SUMMARY

The impact sound insulation characteristics of two combinations of floor covering materials, laid over a 150 mm thick reinforced concrete slab, have been measured.

The measurements were performed in accordance with the requirements of AS ISO 140.6–2006 and AS ISO 140.8–2006.

The performance index numbers, ΔL_w and ΔL_{lin}, have been calculated in accordance with the method specified by AS ISO 717.2–2004, and represent the reduction in impact sound level due to the floor covering materials, when compared to a bare reference floor.

The performance index numbers, $L_{n,w}$ and C_I have been calculated in accordance with the method specified by AS ISO 717.2–2004, and represent the impact sound level measured for the complete floor system; the floor system being the combination of the floor covering materials and the 150 mm thick reinforced concrete slab used in the test. The Impact Insulation Class, IIC, has been calculated in accordance with the method specified by ASTM E989-89, and is also a characteristic of the complete floor system.

1. TEST SPECIMENS

1.1 Materials

The materials forming the floor systems tested are given below in Table 1.

Table 1, Materials

Floor system for test INR183-1	
Materials (from top down)	Details
• 14 mm Engineered Hardwood flooring	Golden Field Prefinished Engineered 3-Ply Parquet hardwood flooring (lacquered 3-strip rustic oak) with tongue and groove edge profiles. Plank size: 14 mm thick x 2200 x 189 mm. Area mass: approx 7.2 kg/m^2.
• GREENEARTH EVA Acoustic underlay	3 mm neoprene underlay with 60 micron vapour barrier Supplied in 20 m^2 rolls, 1100 mm wide, with pre-applied adhesive tape and 8 cm vapour barrier overlap. Area mass: approx 0.36 kg/m^2.
• 150 mm Reinforced Concrete Slab	3.68 x 3.22 m reinforced concrete test slab, 150 mm thick, installed in a purpose-designed opening between two acoustic reverberation chambers; the surrounding concrete being 305 mm thick.
Floor system for test INR183-2	
Materials (from top down)	Details
• 12 mm Timber Laminate flooring	Golden Field GE2-005 “Rose Gum” 12 mm timber laminate flooring with interlocking edge profile. Plank size: 12.3 mm thick x 1800 x 143 mm. Area mass: approx 10.8 kg/m^2.
• GREENEARTH EVA Acoustic underlay	3 mm neoprene underlay with 60 micron vapour barrier Supplied in 20 m^2 rolls, 1100 mm wide, with pre-applied adhesive tape and 8 cm vapour barrier overlap. Area mass: approx 0.36 kg/m^2.
• 150 mm Reinforced Concrete Slab	3.68 x 3.22 m reinforced concrete test slab, 150 mm thick, installed in a purpose-designed opening between two acoustic reverberation chambers; the surrounding concrete being 305 mm thick.

Figure 1, Engineered Hardwood flooring, as installed.

Figure 2, Laminate flooring, as installed.

1.2 Installation

- The floor of the laboratory was swept to remove dirt and foreign material from the surface.
- Lengths of the underlay material were cut from the roll (sufficient length to cover the full width of the slab), laid (vapour barrier down) over the slab, and joined using the tape pre-fitted to the underlay as supplied.
- The engineered hardwood flooring was laid over the underlay, covering the test area of the 150 mm thick concrete test floor of the laboratory.
- Following the first test, the engineered hardwood flooring was removed and replaced with the laminate flooring.
- Installation of both flooring materials was carried out with a combination of some planks left at their original length, and some cut shorter to enable the flooring to be laid covering the full test area of the concrete, and to enable the joins to be staggered, in keeping with normal installation practice.
- Installation was begun by the laboratory's staff, and completed by the client.

2. METHOD OF TEST

2.1 General

The specimen floor covering materials were laid on the 150 mm thick, heavyweight reinforced concrete slab installed in the opening in the common floor/ceiling between a pair of purpose-built reverberation rooms. A standard tapping-machine is operated on the test floor. Measurements of the sound levels in the room underneath, are made at eight different tapping machine positions across the floor and the results averaged. The average impact sound levels measured are converted to normalised values by correcting for the sound absorption characteristics of the room.

2.2 Specific

The measurement was performed to comply with the requirements of AS ISO 140.8-2006 *"Measurement of sound insulation in buildings and building elements – Part 8: Laboratory measurement of the reduction in transmitted impact noise by floor coverings on a standard floor"*, and also with the requirements of AS ISO 140.6-2006 *"Measurement of sound insulation in buildings and building elements – Part 6: Laboratory measurement of sound insulation of floors"*.

3. TEST LABORATORY

Description of Test Facility

The reverberation chambers in which the flooring specimens were installed, and measureents carried out, were of reinforced concrete construction, all the bounding surfaces of which are 305 mm thick. The chambers were designed to exclude external noise, and to minimise structure-borne transmission of noise between the chambers. A heavywieght reinforced concrete slab floor, 150 mm thick, resting on a peripheral support ledge in the floor test aperture, was used as the underlying floor construction with the specimen floor covering materials.

Figure 3 shows the layout and main construction features of the test laboratory.

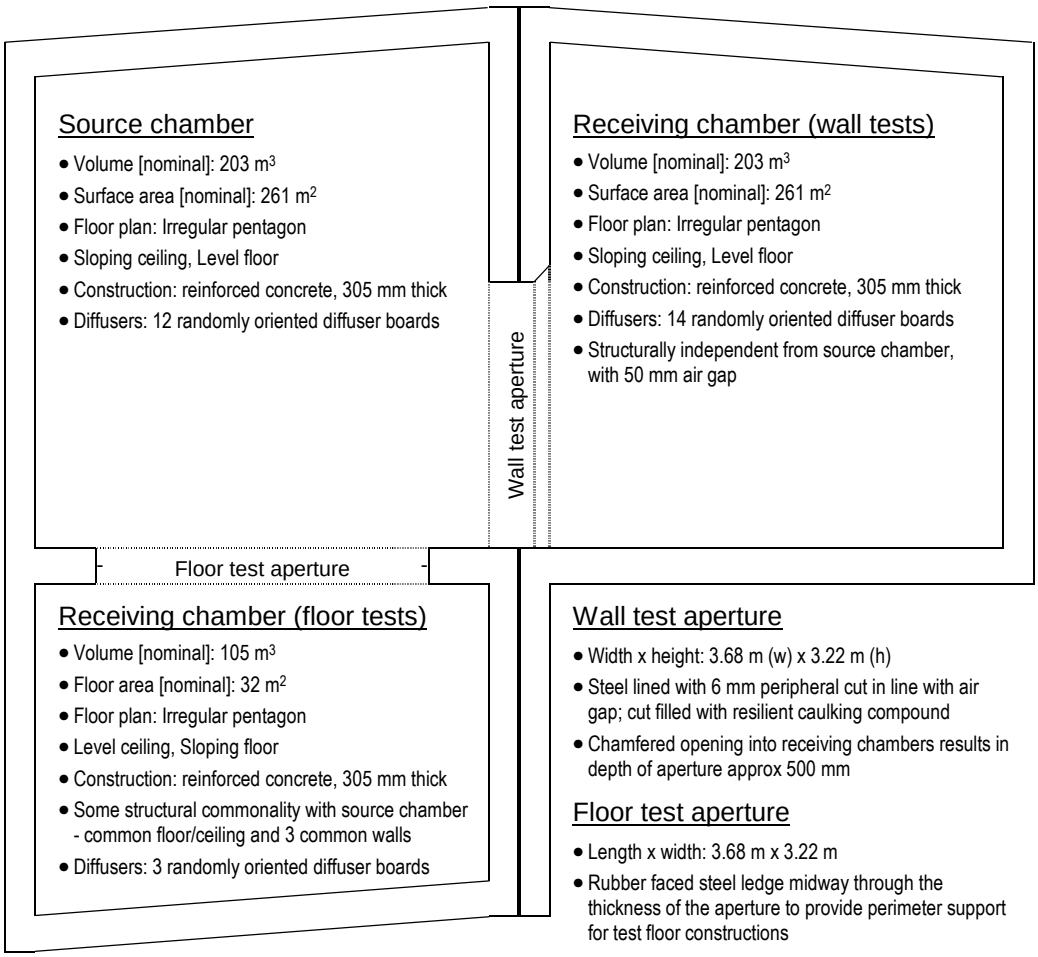


Figure 3, Reverberation chambers used for sound measurements.

4. INSTRUMENTATION AND EQUIPMENT

4.1 Sound Generation (Airborne)

Signal source:
- Broadband random noise generator (pink noise) of Brüel & Kjær PULSE LAN-XI real time analyser

Initial amplification:
- Bruel & Kjaer type 2607 Measuring Amplifier

Signal conditioning:
- Klark Teknik DN27 Graphic Equaliser, used to adjust the relative signal strength in the frequency bands to achieve approximately equal sound levels across the range.

Audio crossover:
- Custom-built apparatus, crossing over between the 1600 and 2000 Hz bands.

Amplification:
- Low freq (≤ 1600 Hz) – Onkyo M-588F
- High freq (≥ 2000 Hz) – Crown DC300A

Speakers:
- Low freq (≤ 1600 Hz) – 300 mm dia Rola 12UX on flat 1 m^2 baffle
- High freq (≥ 2000 Hz) – Twelve 50 mm dia Peerless tweeters in dodecahedron housing

4.2 Sound Generation (Impact)

Apparatus:
- Bruel & Kjaer type 3204 Tapping Machine (rotating cams lift and release in-turn, five 500 g steel weights, so that they drop onto the floor with the energy of a 40 mm fall, at the rate of 10 impacts per second). Machine complies with ISO 140.

4.3 Measurement and Analysis

Microphone:
- Bruel & Kjaer type 4166

Preamplifier:
- Bruel & Kjaer type 2639

Spatial sampling:
- Continuous rotation on 1.67 m radius at 35 s period, Bruel & Kjaer type 3923 rotating boom

Real time analyser:
- Brüel & Kjær PULSE LAN-XI [• simultaneous measurement in all standard 1/3-octave bands (four channel), • reverberation time measurement, • averaging of repeat measurements, • internal power supply for microphones, • noise generator]

Calibrator:
- Bruel & Kjaer type 4220 Pistonphone (nom 124 dB re 20 µPa, 250 Hz)

Calibration status:
- Analyser – current NATA calibration (02/2013)
- Pistonphone – current NATA calibration (04/2011)
- Microphone/preamp – sensitivity of the measuring system from the microphone through to the analyser, was calibrated to the reference signal from the pistonphone prior to measurement

5. MEASUREMENT DETAILS

5.1 Impact Sound Pressure Levels

The impact sound pressure level at each 1/3-octave frequency band, for each floor system, including the bare concrete test slab, was measured with the tapping machine placed in each of nine different locations across the test floor, and the overall level determined by

$$L = 10\log_{10}\left(\frac{1}{n}\sum_{j=1}^{n}10^{L_j/10}\right)\text{dB}$$

5.2 Correction for Background Sound Pressure Level

Background sound pressure levels were measured. Where required by AS ISO 140.6 and AS ISO 140.8, corrections to impact sound pressure levels were made according to the formula

$$L = 10\log_{10}[10^{L_{sb}/10} - 10^{L_b/10}]\text{dB}$$

Where L is the corrected signal level, L_{sb} is the measured signal level, and L_b is the measured background level. A background correction of 1.3 dB is made if the measured signal level is within 6 dB of background; measurement of signal level being limited by background noise. Background corrections are reported in Table 2.

5.3 Normalized Impact Sound Pressure Levels

Impact sound pressure levels were normalized to 10 m^2 absorption area, according to Sabine's formula, after measuring the reverberation times in the receiving room at each 1/3-octave band. The normalized impact sound levels are reported in Table 2.

Table 2, Normalized impact sound pressure levels, including background corrections

Freq (Hz)	Bare 150 mm Thick Concrete Slab		INR183-1 14 mm Engineered Hardwood over GREENEARTH 3 mm Neoprene underlay over 150 mm Concrete slab		INR183-2 12 mm Timber Laminate flooring over GREENEARTH 3 mm Neoprene underlay over 150 mm Concrete slab	
	L_n (dB)		L_n (dB)		L_n (dB)	
100	58.5	-	58.2	-	57.3	-
125	61.1	-	59.4	-	59.3	-
160	63.4	-	62.1	-	62.2	-
200	66.5	-	63.9	-	64.2	-
250	67.1	-	64.8	-	65.6	-
315	68.5	-	65.8	-	66.6	-
400	70.1	-	65.8	-	67.1	-
500	70.0	-	63.5	-	65.1	-
630	70.6	-	61.6	-	63.4	-
800	71.3	-	58.1	-	60.5	-
1000	71.3	-	53.9	-	55.1	-
1250	72.1	-	50.3	-	51.8	-
1600	71.9	-	47.2	-	47.5	-
2000	71.7	-	41.4	-	41.5	-
2500	71.3	-	37.1	-	36.4	-
3150	70.9	-	31.0	-	30.6	-
4000	69.7	-	26.3	-	24.9	-
5000	67.5	-	22.7	-	20.2	0.2
		⇧		⇧		⇧
Background corrections (dB) where applicable, applied to measured SPL before normalizing. (Where the symbol ≤ appears, measured SPL was within 6 dB of background – correction has been limited to 1.3 dB; measurement is limited by background level.)						

5.4 Test Results

Table 3 presents a summary of the impact sound insulation results, including the normalized impact sound pressure levels determined from the test, and the corresponding performance index numbers.

An appendix for each test appears at the end of this report; each appendix summarising the details of the test carried out on one individual floor system.

The Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$), and Spectrum Adaptation Term (C_I) have been determined according to the standard AS ISO 717.2:2004. The Impact Isolation Class (IIC) has been determined according to ASTM E989-89.

Table 3, Summary of results

Test ID No		**INR183-1** $L_{n,w}(C_I)$: 59(-1)		**INR183-2** $L_{n,w}(C_I)$: 60(-1)	
Date of Test	9 April, 2013				
Temp & humidity : Source	18 °C, 71 %RH	19 °C, 65 %RH		19 °C, 68 %RH	
Receiving	19 °C, 67 %RH	19 °C, 67 %RH		19 °C, 66 %RH	
Air pressure	1025 hPa				
Floor System & Covering (top to bottom)	• Concrete slab (reinforced), 150 mm thick, no floor covering	• 14 mm thick Engineered Hardwood • GREENEARTH 3 mm underlay • 150 mm thick reinforced concrete slab		• 12 mm thick Timber Laminate • GREENEARTH 3 mm underlay • 150 mm thick reinforced concrete slab	
Freq, Hz	"L_n" values in accordance with AS ISO 140.6–2006 ⇩	⇩		⇩	
100	58.5	58.2	0.3	57.3	1.2
125	61.1	59.4	1.7	59.3	1.8
160	63.4	62.1	1.3	62.2	1.2
200	66.5	63.9	2.6	64.2	2.3
250	67.1	64.8	2.3	65.6	1.5
315	68.5	65.8	2.7	66.6	1.9
400	70.1	65.8	4.3	67.1	3.0
500	70.0	63.5	6.5	65.1	4.9
630	70.6	61.6	9.0	63.4	7.2
800	71.3	58.1	13.2	60.5	10.8
1000	71.3	53.9	17.4	55.1	16.2
1250	72.1	50.3	21.8	51.8	20.3
1600	71.9	47.2	24.7	47.5	24.4
2000	71.7	41.4	30.3	41.5	30.2
2500	71.3	37.1	34.2	36.4	34.9
3150	70.9	31.0	39.9	30.6	40.3
4000	69.7	26.3	43.4	24.9	44.8
5000	67.5	22.7	44.8	20.2	47.3
			⇧ "ΔL" values in accordance with AS ISO 140.8–2006 ⇩		⇧ ⇩
Performance Index Numbers					
$L_{n,w}$	78	59	-	60	-
C_I	-12	-1	-	-1	-
$L_{n,w}+C_I$	66	58	-	59	-
IIC	29	51	-	50	-
ΔL_w	-	-	17	-	16
ΔL_{lin}	-	-	7	-	6

≤ and ≥ indicate figures, if any, where measurement was limited by proximity to background level.

Officer conducting measurement: Mr. David Truett

Report reviewed by: Dr. Christopher Preston

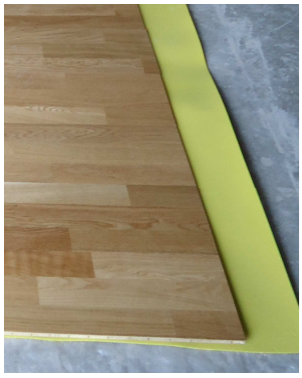
Date report issued: 17 April 2013

Statement of Results (Impact Sound Insulation Test)

CSIRO Test: INR183-1 Commissioned by: **Golden Field Corporation Pty Ltd**

Construction (from top down):

• Engineered Hardwood flooring, 14 mm thick	Golden Field Prefinished Engineered 3-Ply Parquet hardwood flooring (lacquered 3-strip rustic oak) with tongue and groove edge profiles. Plank size: 14 mm thick x 2200 x 189 mm. Area mass: approx 7.2 kg/m^2.
• GREENEARTH EVA Acoustic underlay, 3 mm thick	3 mm neoprene underlay with 60 micron vapour barrier Supplied in 20 m^2 rolls, 1100 mm wide, with pre-applied adhesive tape and 8 cm vapour barrier overlap. Area mass: approx 0.36 kg/m^2.
• 150 mm Reinforced Concrete Slab	3.68 x 3.22 m reinforced concrete test slab, 150 mm thick, installed in a purpose-designed opening between two acoustic reverberation chambers; the surrounding concrete being 305 mm thick. Area mass: approx 360 kg/m^2.
• Ceiling: None	The underside of the concrete slab formed the top surface of the receiving chamber.



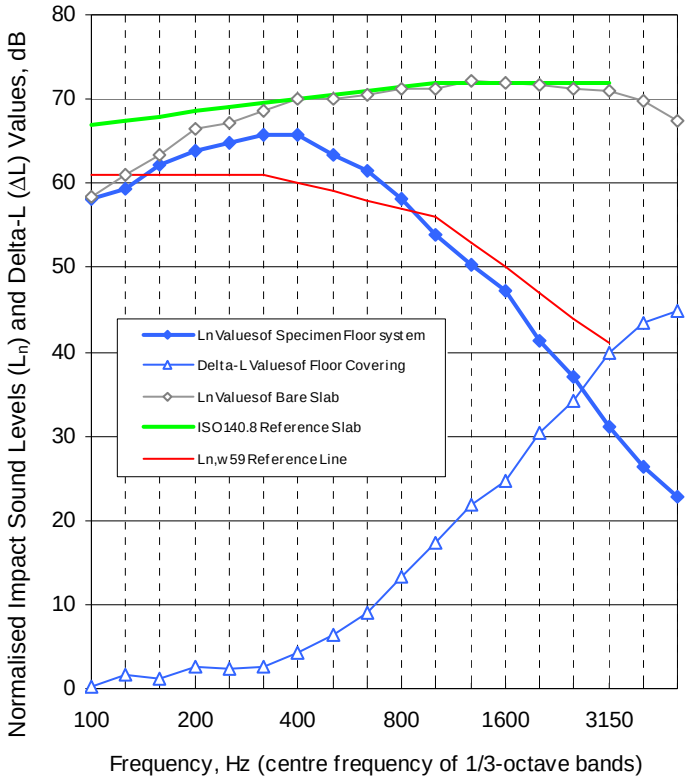
Results $L_{n,w}(C_l)$ = 59(-1)

Freq (Hz)	Normalized Impact SPL (dB) Bare Floor	Normalized Impact SPL (dB) With Floor Covering	Improvement ΔL (dB)
100	58.5	58.2	0.3
125	61.1	59.4	1.7
160	63.4	62.1	1.3
200	66.5	63.9	2.6
250	67.1	64.8	2.3
315	68.5	65.8	2.7
400	70.1	65.8	4.3
500	70.0	63.5	6.5
630	70.6	61.6	9.0
800	71.3	58.1	13.2
1000	71.3	53.9	17.4
1250	72.1	50.3	21.8
1600	71.9	47.2	24.7
2000	71.7	41.4	30.3
2500	71.3	37.1	34.2
3150	70.9	31.0	39.9
4000	69.7	26.3	43.4
5000	67.5	22.7	44.8
ΔL_w	-	-	17
ΔL_{lin}	-	-	7
IIC	29	51	-
$L_{n,w}$	78	59	-
C_l	-12	-1	-
$L_{n,w} + C_l$	66	58	-

Test Conditions

- Date of measurement: 9 April 2013
- Barometric pressure: 1025 hPa
- Source chamber: 19 °C, 65 %RH
- Receiving chamber: 19 °C, 67 %RH

Impact Sound Data for the concrete test-slab with the Floor Covering described above.



Note: ≥ and ≤ indicate levels, if any, where measurability was limited by background level.

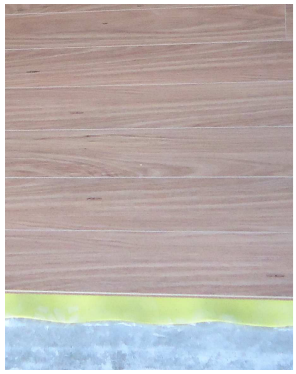
These are the results of testing carried out at CSIRO Acoustic Laboratories, 37 Graham Rd, Highett, Australia 3190 in accordance AS ISO 140.6-2006 and AS ISO 140.8-2006. Calculations have been carried out in accordance with AS ISO 717.2-2004 and ASTM E989-89. This appendix may serve as a statement of results for the particular floor materials described; full details are contained in CSIRO Report INR183/R1.

Statement of Results (Impact Sound Insulation Test)

CSIRO Test: INR183-2 Commissioned by: Golden Field Corporation Pty Ltd

Construction (from top down):

• Timber Laminate flooring, 12 mm thick	Golden Field GE2-005 "Rose Gum" 12 mm timber laminate flooring with interlocking edge profile. Plank size: 12.3 mm thick x 1800 x 143 mm. Area mass: approx 10.8 kg/m^2.
• GREENEARTH EVA Acoustic underlay, 3 mm thick	3 mm neoprene underlay with 60 micron vapour barrier Supplied in 20 m^2 rolls, 1100 mm wide, with pre-applied adhesive tape and 8 cm vapour barrier overlap. Area mass: approx 0.36 kg/m^2.
• 150 mm Reinforced Concrete Slab	3.68 x 3.22 m reinforced concrete test slab, 150 mm thick, installed in a purpose-designed opening between two acoustic reverberation chambers; the surrounding concrete being 305 mm thick. Area mass: approx 360 kg/m^2.
• Ceiling: None	The underside of the concrete slab formed the top surface of the receiving chamber.



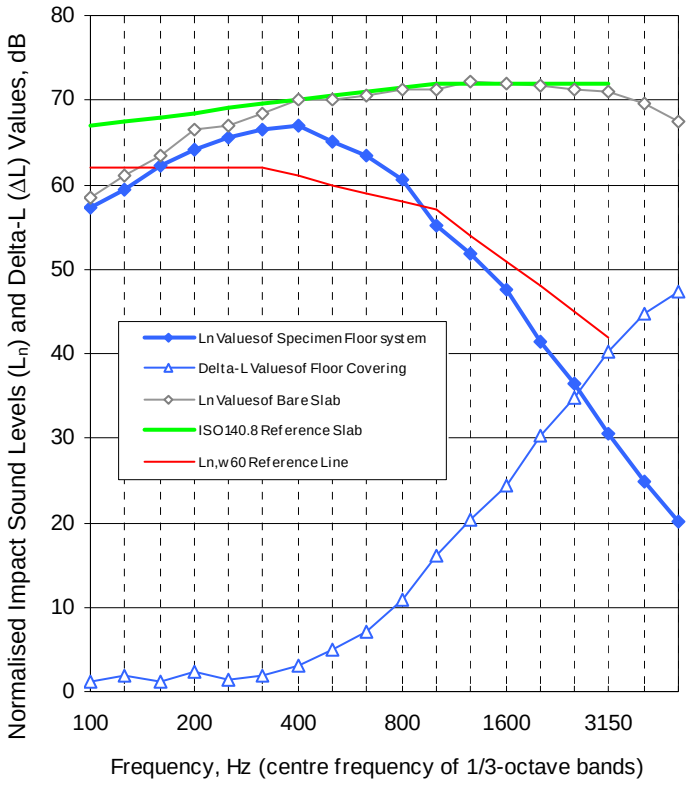
Results $L_{n,w}(C_I) = 60(-1)$

Freq (Hz)	Normalized Impact SPL (dB) Bare Floor	Normalized Impact SPL (dB) With Floor Covering	Improvement ΔL (dB)
100	58.5	57.3	1.2
125	61.1	59.3	1.8
160	63.4	62.2	1.2
200	66.5	64.2	2.3
250	67.1	65.6	1.5
315	68.5	66.6	1.9
400	70.1	67.1	3.0
500	70.0	65.1	4.9
630	70.6	63.4	7.2
800	71.3	60.5	10.8
1000	71.3	55.1	16.2
1250	72.1	51.8	20.3
1600	71.9	47.5	24.4
2000	71.7	41.5	30.2
2500	71.3	36.4	34.9
3150	70.9	30.6	40.3
4000	69.7	24.9	44.8
5000	67.5	20.2	47.3
ΔL_w	-	-	16
ΔL_{lin}	-	-	6
IIC	29	50	-
$L_{n,w}$	78	60	-
C_I	-12	-1	-
$L_{n,w} + C_I$	66	59	-

Test Conditions

- Date of measurement: 9 April 2013
- Barometric pressure: 1025 hPa
- Source chamber: 19 °C, 68 %RH
- Receiving chamber: 19 °C, 66 %RH

Impact Sound Data for the concrete test-slab with the Floor Covering described above.



Note: ≥ and ≤ indicate levels, if any, where measurability was limited by background level.

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