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ON THE REASONS OF THE REVISION OF ISO 16283-3: FIRST RESULTS OF MEASUREMENT CAMPAIGN ON LOUDSPEAKERS

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ABSTRACT

The facade sound insulation measurements method is standardized in ISO 16283-3, which is being revised.
The reasons for the revision are multiple. First, the dimensions and volumes included in the standard could not be sufficient to consider some higher volumes like open-plan offices and classrooms. Second, the instructions for bigger façades are not sufficiently clear in particular situations. Therefore, an annex like the one in the first and second parts of the standard is required. Third, it was argued that the preferred method to estimate the global sound insulation of a façade would be the global loudspeaker instead of the actual traffic noise (road, railway or aircraft). Fourth, the use and qualification of the directional or omnidirectional sound source were questioned. Fifth, the right positioning of the outside loudspeaker will be analyzed.
This paper presents the first results of the experimental measurement campaign on the qualification of the sound sources for measuring the global façade sound insulation.

Keywords: *ISO 16283-3; façade sound insulation; loudspeakers; source directivity.*

1. INTRODUCTION

The standard ISO 140 (all parts) - Measurement of sound insulation in buildings and of building elements – was revised in 2010 by ISO 10140 (all parts) for Laboratory measurements. Instead, for field measurements, it was revised by ISO 16283 (all parts) [1], starting in 2014 with part 1 - sound insulation between rooms, then in 2015 part 2 - impact sound insulation and finally in 2016 part 3 - façade sound insulation.
The new version of this standard ISO 16283 (all parts) includes some differences respect to ISO 140 parts 4, 5 and 7:

a) It applies to rooms in which the sound field can or can not approximate to a diffuse field;
b) It clarifies how operators can measure the sound field using a hand-held microphone or sound level meter,
c) It includes additional guidance previously contained in ISO 140-14.

This last change is included only in parts 1 and 2, while part 3 lacs of this additional guidance. One of the goals of the ISO 16283-3 revision is to add an annex including all the additional guidance for particular situations and the position of the sound source, particularly for higher volumes. The series ISO 16283 is intended only for room volume up to 250m^3. Therefore, it is necessary to consider adding some guidance for higher volumes, like open-plan offices and classrooms. Moreover, the use of more than one position of the outside loudspeaker, also for narrow rooms, could be useful. In fact, it was found [2] that in the case of a corner façade, when multiple source positions are used for the measurements, the influence of the non-acoustic parameters can be neglected.
Moreover, ISO 16283 (all parts) includes the low frequencies method for measuring down to 50 Hz in case of small room volume (less than 25m^3). In addition, in part 3, an annex with loudspeaker requirements was added. This annex gives the indications for omnidirectional loudspeakers, allowing the use of omnidirectional sound sources without checking the loudspeaker's directivity as indicated in the body of the standard as follows. "*The*

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directivity of the loudspeaker in the free field shall be such that the local differences in the sound pressure level in each frequency band of interest are less than 5 dB, measured on an imaginary surface of the same size and orientation as the test specimen". Checking the directivity of the sound source for each specimen on an imaginary surface is highly demanding in terms of time and cost. Therefore, it is necessary to implement a method to qualify the sound source used for façade sound insulation measurements. Actually, in a previous study it was demonstrated that, especially at high frequencies, there could be an influence on the measurement results deriving not only from the correct positioning of the speaker but also from the type of speaker used [3]. This paper presents the results of the first measurement campaign on the loudspeakers.

2. PLANNING OF THE MEASUREMENT CAMPAIGN

In order to establish a method of verification and comparison of the sound sources, a measurement campaign has been set up to assess the distribution of the sound pressure level in a facade. It was also decided to compare four different sound sources, two directional and two omnidirectional.

The two directional sound sources were:

- B&K 4224 single-way amplified speaker with broadband speaker
- Phon-X NGS-1 two-way amplified speaker (X-over 3.5 kHz) with 8" woofer and 1" horn tweeter.

The two omnidirectional sound sources were:

- Phon-X Omni dodecahedron with 4" broadband speakers
- DIY dodecahedron with 5" B&C Model 5MDN38 speakers [4].

Each sound source was powered by its specific signal amplifier, and all of them use the same noise generator consisting of a MOTU AVB Lite sound card that reproduced a pink noise.

A 22x10 m (L x H) flat reinforced concrete surface of an industrial hall was chosen as the test façade. In order to reduce the variables associated with the test conditions, the façade portion used was free of fixtures or irregularities. Only a part of the industrial hall's facade has been identified to simulate a hypothetical flat facade on the first floor of a building whose center (the point on which the sources were addressed) is located at the height of 5.2 m. The directional and omnidirectional sources were positioned at a distance of 5.2m. The omnidirectional sources were positioned with one of the speaker facing the facade. While the directional sources were positioned with the sound incidence angle equal to 45°.

Another change in ISO 16283-3 will be the description of the configuration for the positioning of sound source, in order to clarify the sound incidence angle better. The Italian mirror committee proposed Figure 1 to replace Figure 3 of ISO 16283-3 [5].

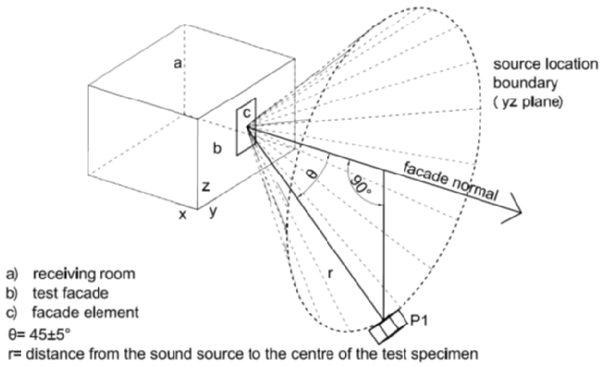

Figure 1. Sketch of loudspeaker positions, where P1 marks the loudspeaker positions.

Figure 2. Image of test area and instrumentation used.

To measure the sound pressure level, a microphone grid of 10x12 microphones with a horizontal pitch of 0.8 m and a vertical pitch of 0.4 m from the minimum height of 1.5m and 2 meters away from the façade, was used. The total covered area is about 38 m^2. The acquisition system was an 8-channel analyzer, 6 of them were used in microphone array, and other two were used as control points, leaving them fixed during each acquisition and for each speaker. The first control point was at the height of 1.5 m from the ground and 2 meters from the facade, and the second was at a height of 5.2 meters and 2.4 meters from the facade.

Figure 3. Side view of the microphones array.

Figure 4. Sound sources, from front to back: DIY black dodecahedron; Phon-X Omni red dodecahedron; Phon-X NGS-1 directional sound source in the middle; B&K 4224 directional sound source behind.

3. PRELIMINARY RESULTS

The following graphs show the results for all loudspeakers at 5.2m above the ground, which corresponds to a height of 1.5m in a hypothetical receiving environment on the first floor.

To assess the homogeneity of the sound field on the facade, the differences in the sound pressure levels of each point with respect to the central point (microphone in the center of the target facade, at the height of 5.2m and distance 2m from the facade) concerning horizontal lateral displacements were calculated. The cases where the difference between these levels was greater than 5 dB were highlighted in red. This criterion is indicated in ISO 16283-3, as said before (“*The directivity of the loudspeaker in the free field shall be such that the local differences in the sound pressure level in each frequency band of interest are less than 5 dB*”).

In the case of B&K 4224, it can be seen (Figure 5) a deviation at 200 Hz of 6 dB at only 3.2 m compared to the reference microphone. This result was also found in the measures with the other directional sound source, while with the two dodecahedrons, this deviation is less evident. This behavior, which occurs only at this frequency, must be deeply studied to give a correct interpretation, whether it depends on the constructive characteristics of the facade, or the sound sources used. In addition, due to the directivity of the source itself, starting at 1600 Hz, the horizontal aperture limit is reduced to 6.4 meters and decreases with increasing frequency.

The limit fixed for these graphs is 5 dB. Based on this criterion, indicated by ISO standard, the portions of the facade measurable with a single source position are very small in some cases, at most 3-4 meters.

Where the omnidirectional source has been used (Figure 8), limitations in the zone coverage at 800 Hz and 1000 Hz are evident. In particular, at 2500 Hz, the coverage is reduced to 1.6m.

The omnidirectionality of dodecahedral sources depends on diffraction effects on the edges of the dodecahedron; for example, a dodecahedron with a side of 17 cm loses omnidirectionality from about 2000 Hz.

After this frequency, the directivity of each speaker becomes evident; the dodecahedron is transformed from an omnidirectional source to a set of 12 sources with different spatial directivity [6].

Despite this, it should be stressed that the choice of the sound source must not only be in function of the cover of the façade, but also and above all in function of the so-called power that can reach the facade. In fact, in Nordtest project report [7], in which the method for verifying the coverage of the sound sources was developed, the indication of using a directional sound source is precisely due to the fact that the sound power is to be preferred.

100 Hz	13,8	7,2	10,0	5,1	4,0	1,2	-0,1	-0,1	0,2	**0,0**	0,2	-0,1	-0,1	1,2	4,0	5,1	10,0	7,2	13,8
125 Hz	9,2	6,8	4,6	2,7	1,3	0,4	1,7	1,5	0,7	**0,0**	0,7	1,5	1,7	0,4	1,3	2,7	4,6	6,8	9,2
160 Hz	2,1	-0,6	-1,2	-2,1	-2,4	-0,6	0,2	-0,7	-0,6	**0,0**	-0,6	-0,7	0,2	-0,6	-2,4	-2,1	-1,2	-0,6	2,1
200 Hz	0,9	-0,3	-0,6	2,7	3,8	6,2	2,8	3,5	2,5	**0,0**	2,5	3,5	2,8	6,2	3,8	2,7	-0,6	-0,3	0,9
250 Hz	4,1	6,8	8,3	1,4	1,2	1,1	1,0	0,9	1,3	**0,0**	1,3	0,9	1,0	1,1	1,2	1,4	8,3	6,8	4,1
315 Hz	8,5	5,0	1,1	3,1	4,0	4,0	2,0	-0,1	-0,9	**0,0**	-0,9	-0,1	2,0	4,0	4,0	3,1	1,1	5,0	8,5
400 Hz	5,7	5,5	7,2	4,0	3,0	1,5	1,2	0,7	0,8	**0,0**	0,8	0,7	1,2	1,5	3,0	4,0	7,2	5,5	5,7
500 Hz	13,8	9,0	7,2	5,5	3,9	1,6	1,3	0,4	0,1	**0,0**	0,1	0,4	1,3	1,6	3,9	5,5	7,2	9,0	13,8
630 Hz	8,5	9,7	4,8	3,1	0,8	1,6	1,4	0,6	-0,1	**0,0**	-0,1	0,6	1,4	1,6	0,8	3,1	4,8	9,7	8,5
800 Hz	8,4	8,2	4,4	3,1	1,8	1,7	1,1	0,9	-0,1	**0,0**	-0,1	0,9	1,1	1,7	1,8	3,1	4,4	8,2	8,4
1 kHz	7,5	7,3	4,7	5,0	4,1	2,0	1,8	0,9	0,2	**0,0**	0,2	0,9	1,8	2,0	4,1	5,0	4,7	7,3	7,5
1.25 kHz	5,9	6,5	5,7	4,0	1,9	1,5	0,9	0,6	0,1	**0,0**	0,1	0,6	0,9	1,5	1,9	4,0	5,7	6,5	5,9
1.6 kHz	13,4	10,0	8,6	8,1	5,5	3,7	2,0	0,7	0,5	**0,0**	0,5	0,7	2,0	3,7	5,5	8,1	8,6	10,0	13,4
2 kHz	16,2	16,6	12,7	10,9	5,6	4,6	3,2	1,1	0,2	**0,0**	0,2	1,1	3,2	4,6	5,6	10,9	12,7	16,6	16,2
2.5 kHz	18,8	19,4	14,7	13,3	7,8	6,2	3,9	1,5	0,5	**0,0**	0,5	1,5	3,9	6,2	7,8	13,3	14,7	19,4	18,8
3.15 kHz	16,8	16,4	16,3	14,7	11,1	9,3	6,8	2,4	0,1	**0,0**	0,1	2,4	6,8	9,3	11,1	14,7	16,3	16,4	16,8
4 kHz	18,8	19,3	16,3	14,3	10,4	7,0	3,6	1,4	-0,6	**0,0**	-0,6	1,4	3,6	7,0	10,4	14,3	16,3	19,3	18,8
5 kHz	15,6	18,2	15,5	17,4	11,1	8,8	3,8	0,5	-1,5	**0,0**	-1,5	0,5	3,8	8,8	11,1	17,4	15,5	18,2	15,6
	7.2 m	6.4 m	5.6 m	4.8 m	4 m	3.2 m	2.4 m	1.6 m	0.8 m	0 m	0.8 m	1.6 m	2.4 m	3.2 m	4 m	4.8 m	5.6 m	6.4 m	7.2 m

Figure 5. Directional source B&K 4224. Frequencies variation of sound levels with respect to the center of the facade for horizontal displacement at 5.2m height.

100 Hz	13,6	10,2	7,1	4,3	3,5	0,9	-0,4	0,4	-0,2	**0,0**	-0,2	0,4	-0,4	0,9	3,5	4,3	7,1	10,2	13,6
125 Hz	8,4	6,0	3,6	2,2	1,0	0,6	1,1	1,2	-0,2	**0,0**	-0,2	1,2	1,1	0,6	1,0	2,2	3,6	6,0	8,4
160 Hz	2,3	0,4	-0,8	-1,0	-1,5	0,9	1,7	-0,6	-0,8	**0,0**	-0,8	-0,6	1,7	0,9	-1,5	-1,0	-0,8	0,4	2,3
200 Hz	-0,9	-0,3	-1,4	1,3	3,0	6,0	2,7	2,6	3,4	**0,0**	3,4	2,6	2,7	6,0	3,0	1,3	-1,4	-0,3	-0,9
250 Hz	2,7	6,4	8,4	3,0	2,4	1,5	0,6	2,5	3,7	**0,0**	3,7	2,5	0,6	1,5	2,4	3,0	8,4	6,4	2,7
315 Hz	9,1	5,9	2,5	4,2	4,8	3,9	1,6	-0,4	-0,6	**0,0**	-0,6	-0,4	1,6	3,9	4,8	4,2	2,5	5,9	9,1
400 Hz	6,7	7,1	8,0	3,1	1,9	0,7	0,1	-0,3	-1,1	**0,0**	-1,1	-0,3	0,1	0,7	1,9	3,1	8,0	7,1	6,7
500 Hz	11,0	6,0	5,1	2,5	1,7	0,1	0,2	-0,8	-1,4	**0,0**	-1,4	-0,8	0,2	0,1	1,7	2,5	5,1	6,0	11,0
630 Hz	7,1	8,6	3,6	2,0	0,5	1,4	1,6	0,9	0,9	**0,0**	0,9	0,9	1,6	1,4	0,5	2,0	3,6	8,6	7,1
800 Hz	3,9	4,7	2,1	0,2	-0,4	1,8	0,0	0,5	-0,6	**0,0**	-0,6	0,5	0,0	1,8	-0,4	0,2	2,1	4,7	3,9
1 kHz	4,9	4,8	2,4	3,5	3,4	1,7	1,4	0,5	-0,1	**0,0**	-0,1	0,5	1,4	1,7	3,4	3,5	2,4	4,8	4,9
1.25 kHz	7,7	9,4	6,7	4,7	3,2	1,6	1,2	0,2	-0,5	**0,0**	-0,5	0,2	1,2	1,6	3,2	4,7	6,7	9,4	7,7
1.6 kHz	8,2	7,1	4,8	4,4	3,8	2,7	2,4	0,7	0,7	**0,0**	0,7	0,7	2,4	2,7	3,8	4,4	4,8	7,1	8,2
2 kHz	6,0	7,7	3,4	4,0	1,8	1,3	1,3	0,2	-0,3	**0,0**	-0,3	0,2	1,3	1,3	1,8	4,0	3,4	7,7	6,0
2.5 kHz	1,7	7,3	1,2	2,6	1,2	1,7	1,9	0,6	-0,3	**0,0**	-0,3	0,6	1,9	1,7	1,2	2,6	1,2	7,3	1,7
3.15 kHz	6,3	6,0	6,6	4,3	2,0	1,2	2,3	0,9	-0,3	**0,0**	-0,3	0,9	2,3	1,2	2,0	4,3	6,6	6,0	6,3
4 kHz	6,8	6,8	6,1	3,1	3,3	1,9	2,4	2,1	-0,6	**0,0**	-0,6	2,1	2,4	1,9	3,3	3,1	6,1	6,8	6,8
5 kHz	3,3	3,8	2,0	0,7	-1,0	-2,2	-1,9	-2,2	-2,3	**0,0**	-2,3	-2,2	-1,9	-2,2	-1,0	0,7	2,0	3,8	3,3
	7.2 m	6.4 m	5.6 m	4.8 m	4 m	3.2 m	2.4 m	1.6 m	0.8 m	0 m	0.8 m	1.6 m	2.4 m	3.2 m	4 m	4.8 m	5.6 m	6.4 m	7.2 m

Figure 6. Two-way directional source NGS-1. Frequencies variation of sound levels with respect to the center of the facade for horizontal movement at 5.2m height.

100 Hz	0,8	-0,1	6,1	3,8	2,2	-2,5	-0,8	-0,6	-2,5	**0,0**	-2,5	-0,6	-0,8	-2,5	2,2	3,8	6,1	-0,1	0,8
125 Hz	5,9	4,6	4,0	2,2	1,1	-0,3	1,2	1,0	-0,1	**0,0**	-0,1	1,0	1,2	-0,3	1,1	2,2	4,0	4,6	5,9
160 Hz	4,5	2,4	1,9	1,1	1,2	2,2	2,6	1,2	0,6	**0,0**	0,6	1,2	2,6	2,2	1,2	1,1	1,9	2,4	4,5
200 Hz	-0,3	-0,4	-0,8	2,9	3,1	3,7	1,9	1,1	0,7	**0,0**	0,7	1,1	1,9	3,7	3,1	2,9	-0,8	-0,4	-0,3
250 Hz	3,5	7,7	8,2	1,4	1,0	0,6	-0,3	0,4	-0,6	**0,0**	-0,6	0,4	-0,3	0,6	1,0	1,4	8,2	7,7	3,5
315 Hz	4,0	1,5	-1,0	-2,0	-0,7	-2,6	1,0	0,7	1,0	**0,0**	1,0	0,7	1,0	-2,6	-0,7	-2,0	-1,0	1,5	4,0
400 Hz	2,4	2,5	4,2	2,4	4,2	2,0	0,8	1,6	1,3	**0,0**	1,3	1,6	0,8	2,0	4,2	2,4	4,2	2,5	2,4
500 Hz	2,3	0,3	-2,3	-2,0	0,6	0,1	0,6	1,3	5,3	**0,0**	5,3	1,3	0,6	0,1	0,6	-2,0	-2,3	0,3	2,3
630 Hz	-0,5	1,3	1,9	-0,8	-0,9	-1,5	2,8	0,8	1,8	**0,0**	1,8	0,8	2,8	-1,5	-0,9	-0,8	1,9	1,3	-0,5
800 Hz	2,9	7,4	9,8	5,3	3,7	2,2	3,6	1,8	1,6	**0,0**	1,6	1,8	3,6	2,2	3,7	5,3	9,8	7,4	2,9
1 kHz	5,3	9,2	7,6	6,0	3,8	1,1	0,9	0,4	0,2	**0,0**	0,2	0,4	0,9	1,1	3,8	6,0	7,6	9,2	5,3
1.25 kHz	3,5	4,4	2,9	2,3	0,6	-0,4	0,1	0,0	0,5	**0,0**	0,5	0,0	0,1	-0,4	0,6	2,3	2,9	4,4	3,5
1.6 kHz	-0,4	0,3	-0,9	-0,1	-0,2	-1,0	0,5	1,1	0,0	**0,0**	0,0	1,1	0,5	-1,0	-0,2	-0,1	-0,9	0,3	-0,4
2 kHz	0,4	-0,3	0,3	3,8	0,8	0,4	1,1	2,0	1,2	**0,0**	1,2	2,0	1,1	0,4	0,8	3,8	0,3	-0,3	0,4
2.5 kHz	0,9	4,0	-1,2	-3,2	-1,8	-0,6	2,0	2,7	2,3	**0,0**	2,3	2,7	2,0	-0,6	-1,8	-3,2	-1,2	4,0	0,9
3.15 kHz	0,5	6,5	4,1	4,2	1,5	0,2	2,2	4,3	2,6	**0,0**	2,6	4,3	2,2	0,2	1,5	4,2	4,1	6,5	0,5
4 kHz	-2,5	5,5	0,5	-0,6	-2,0	-1,9	-1,6	2,1	-0,2	**0,0**	-0,2	2,1	-1,6	-1,9	-2,0	-0,6	0,5	5,5	-2,5
5 kHz	-1,4	6,5	4,1	0,1	0,1	-0,3	-0,1	2,6	-1,4	**0,0**	-1,4	2,6	-0,1	-0,3	0,1	0,1	4,1	6,5	-1,4
	7.2 m	6.4 m	5.6 m	4.8 m	4 m	3.2 m	2.4 m	1.6 m	0.8 m	0 m	0.8 m	1.6 m	2.4 m	3.2 m	4 m	4.8 m	5.6 m	6.4 m	7.2 m

Figure 7. Omnidirectional source Phon-X Omni. Frequencies variation of sound levels with respect to the center of the facade for horizontal displacement at 5.2m height.

100 Hz	10,3	11,3	8,9	4,1	3,1	1,0	-0,3	-0,2	-0,7	**0,0**	-0,7	-0,2	-0,3	1,0	3,1	4,1	8,9	11,3	10,3
125 Hz	8,5	7,5	4,6	2,5	1,5	0,8	1,5	1,1	0,2	**0,0**	0,2	1,1	1,5	0,8	1,5	2,5	4,6	7,5	8,5
160 Hz	5,4	3,4	2,4	1,5	1,5	3,0	2,6	1,4	0,8	**0,0**	0,8	1,4	2,6	3,0	1,5	1,5	2,4	3,4	5,4
200 Hz	1,2	1,0	0,8	3,5	3,5	4,3	1,7	0,8	0,1	**0,0**	0,1	0,8	1,7	4,3	3,5	3,5	0,8	1,0	1,2
250 Hz	3,6	7,2	6,7	0,5	-1,0	-1,4	-0,9	-1,0	-2,3	**0,0**	-2,3	-1,0	-0,9	-1,4	-1,0	0,5	6,7	7,2	3,6
315 Hz	5,6	2,0	-2,8	-1,7	-1,2	-1,0	0,6	0,4	1,5	**0,0**	1,5	0,4	0,6	-1,0	-1,2	-1,7	-2,8	2,0	5,6
400 Hz	2,9	3,0	4,5	2,9	5,0	4,8	0,4	2,4	4,0	**0,0**	4,0	2,4	0,4	4,8	5,0	2,9	4,5	3,0	2,9
500 Hz	1,9	-0,2	-3,5	-2,5	-0,6	3,1	2,9	2,9	1,3	**0,0**	1,3	2,9	2,9	3,1	-0,6	-2,5	-3,5	-0,2	1,9
630 Hz	4,8	4,8	5,6	0,8	1,8	3,1	3,9	2,0	0,4	**0,0**	0,4	2,0	3,9	3,1	1,8	0,8	5,6	4,8	4,8
800 Hz	7,7	10,4	9,0	9,6	5,6	5,4	3,7	1,8	1,3	**0,0**	1,3	1,8	3,7	5,4	5,6	9,6	9,0	10,4	7,7
1 kHz	10,4	9,0	6,8	5,2	3,7	1,7	1,4	0,5	0,3	**0,0**	0,3	0,5	1,4	1,7	3,7	5,2	6,8	9,0	10,4
1.25 kHz	2,7	2,4	1,8	0,2	-0,5	-0,6	-0,2	-0,4	0,7	**0,0**	0,7	-0,4	-0,2	-0,6	-0,5	0,2	1,8	2,4	2,7
1.6 kHz	1,8	0,5	1,1	2,3	1,4	0,6	1,4	1,0	1,9	**0,0**	1,9	1,0	1,4	0,6	1,4	2,3	1,1	0,5	1,8
2 kHz	1,3	1,7	0,3	0,4	-1,5	-2,6	-0,3	0,7	0,9	**0,0**	0,9	0,7	-0,3	-2,6	-1,5	0,4	0,3	1,7	1,3
2.5 kHz	6,2	7,5	4,6	4,7	5,3	5,6	7,0	8,1	3,5	**0,0**	3,5	8,1	7,0	5,6	5,3	4,7	4,6	7,5	6,2
3.15 kHz	3,6	2,4	0,5	-1,7	-2,2	-0,9	2,0	3,5	1,4	**0,0**	1,4	3,5	2,0	-0,9	-2,2	-1,7	0,5	2,4	3,6
4 kHz	5,8	7,3	5,6	4,0	2,8	0,3	2,2	2,9	0,3	**0,0**	0,3	2,9	2,2	0,3	2,8	4,0	5,6	7,3	5,8
5 kHz	6,1	7,1	4,8	5,3	4,2	5,3	4,8	3,3	2,1	**0,0**	2,1	3,3	4,8	5,3	4,2	5,3	4,8	7,1	6,1
	7.2 m	6.4 m	5.6 m	4.8 m	4 m	3.2 m	2.4 m	1.6 m	0.8 m	0 m	0.8 m	1.6 m	2.4 m	3.2 m	4 m	4.8 m	5.6 m	6.4 m	7.2 m

Figure 8. Omnidirectional DIY source. Frequencies variation of sound levels with respect to the centre of the facade for horizontal displacement at 5.2m height.

A comparison of the graphs shows that the two sound sources with a wider coverage angle appear to be the two-way directional speaker NGS-1 (Figure 6) and the dodecahedron Phon-X Omni, the one with the smaller dimensions (Figure 7). This behavior has different explanation depending on the source. On the one hand, thanks to a horn tweeter, the two-way directional speaker NGS-1 has a more regular and homogeneous directivity at high frequencies. On the other hand, the dodecahedron Phon-X Omni, with a 12 cm side, becomes directive above 2500 Hz.

4. CONCLUSIONS

The preliminary measurement campaign shows how important it is to know the opening of the sound source that is used for facade sound insulation measurements in order to know what the coverage for the measurement could be and, consequently, the correct number of positions of the sound source to use.

These first results provide a basis for setting up a source qualification method for facade measurements, which is under study.

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