

# **ACOUSTIC PERFORMANCES OF AN HEMIANECHOIC ROOM FOR ELECTROMAGNETIC COMPATIBILITY TESTS**

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## **Abstract**

An investigation on the acoustical characteristics of an electromagnetic hemianechoic room is here proposed. The research has been carried out within an agreement between the Perugia University Acoustic Laboratory and Angelantoni Industrie S.p.a. Angelantoni Industrie hemianechoic room has been investigated. The room has been created for electromagnetic compatibility tests. It is fully insulated from the outside environment and it guarantees more than 10 KOhms of insulating power. A hybrid solution has been chosen for the anechoic lining of walls and ceiling; the 'quiet zone' is covered by 24" cones coupled to ferrite tiles whereas the remaining parts are covered with 36" cones. No fixed anechoic insulation is on the floor (hemianechoic type). An acoustic measurement campaign has been carried out in order to verify if the investigated room is characterized also by high acoustic hemianechoic performances. Measurements have been led according to ISO 3745. Measurement results have shown that the investigated room, differently from the acoustic typical hemianechoic rooms, accords to ISO 3745 only for 315-20000 Hz frequency range and for a 2.5 m radius hemispheric surface.

## **INTRODUCTION**

The European Directive 89/336/EEC on Electromagnetic Compatibility is now operative all over Europe [1]. Since electronic components have been widely used practically in any field, new safety issues are becoming more and more urgent: among

them, for example, the need to operate any electronic appliance without causing interference to nearby systems or without being disturbed by other equipment. In this context, anechoic rooms represent the ideal environment where to evaluate electromagnetic interference and where to perform qualification tests aimed at guaranteeing that products comply with the European standards. Anechoic and hemianechoic rooms for electromagnetic compatibility tests are often equipped by absorbing coning surfaces; these elements are often realized by sound absorbing material. Thus, an hemianechoic room for electromagnetic compatibility tests may have also good sound absorbing properties. This paper deals with an experimental investigation on an hemianechoic room for electromagnetic compatibility test. In particular, the room acoustic characteristics have been studied. A measurement campaign has been carried out according to ISO 3745 [2]. Measurement results have shown that the investigated room may be considered an hemianechoic room for acoustic tests only for frequencies over 300 Hz and under 2.5 m radius measurement surfaces.

## **THE ANECHOIC ROOM**

The investigated room is an anechoic room for electromagnetic compatibility tests which has been realized by Angelantoni Industrie S.p.a., an Italian factory which uses the room to perform quality and safety tests on their wide range of products. The research has been carried out within an agreement between the Perugia University Acoustic Laboratory and Angelantoni Industrie S.p.a. The room is completely electromagnetically insulated from the external environment; besides, the hemianechoic room allows the repeatability of the tests and the result objectiveness thanks to the high degree of electromagnetic absorption of the fields produced inside. Room dimensions are 6x9x6.5 m. It is grounded on one point only and it guarantees more than 10 KOhms of insulating power. The attenuation levels of the shielded room are indicated in Table 1.

*Table 1: room attenuation levels*

Field	Frequency	Attenuation
H	100 kHz	> 80 dB
H	1 MHz	> 100 dB
E	100 kHz	> 80 dB
E	1 MHz	> 100 dB
E	10 MHz	> 100 dB
E	100 MHz	> 100 dB
PW	400 MHz	> 100 dB
PW	1000 MHz	> 100 dB
PW	10000 MHz	> 100 dB

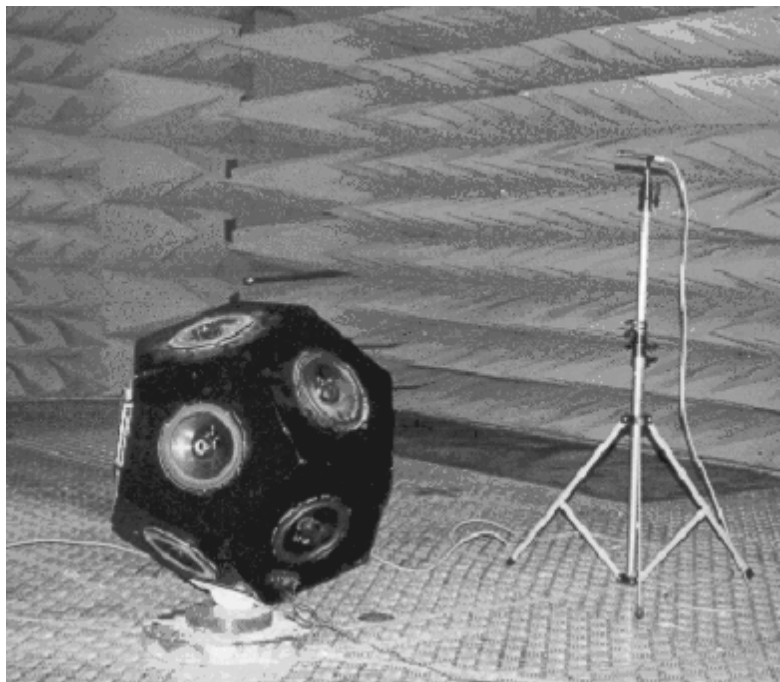
The hemianechoic room is equipped with the following openings:

- a double-wing main entrance door (4x3.5 m) for the tests instrumentation movement;
- a single-wing service door (1.2x2 m) for the access of the operators;
- port holes for connectors for power supply and air-conditioner connections.

The embossed aluminium plate floor can support up to 3000 kg concentrated on four points of a square whose side is 20 cm wide. An opening in the middle of the floor is connected to a drain hole and allows the discharge of accidental water leaks from the equipment under test. A hybrid solution has been chosen for the anechoic lining of walls and ceiling; the 'quiet zone' is covered by 24" cones coupled to ferrite tiles whereas the remaining parts are covered with 36" cones (see Figure 1). No fixed anechoic insulation is needed on the floor (hemianechoic type).

### MEASUREMENT METHOD FOR ACOUSTIC CHARACTERIZATION

A measurement campaign has been carried out according to ISO 3745 [2]; an omni directional dodecahedral source has been placed on the floor on the room floor centre (see Figure 1). Measurements have been carried out by means of Symphonie data acquisition system. A white noise sequence has been generated by the dodecahedral source driven by the data processing system. Sound pressure levels have been picked up by a G.R.A.S. microphone (model 40AR) along 5 paths not parallel to the reflecting floor (see Figure 2). Measurements points have been chosen from a 50 cm distance from the noise source to the maximum available distance. Distance between two adjacent points is 10 cm for each measurement path. Figure 1 shows some measurement phases.



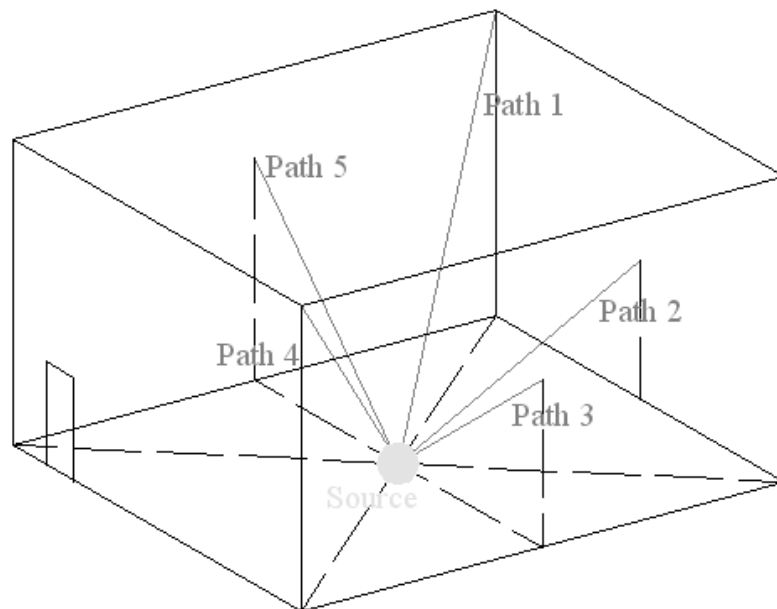
*Figure 1: Measurement phases*

Measured sound pressure levels have been compared to the free field ones; free field levels have been estimated by the following method:

- noise source power spectrum has been evaluated by an intensimetric campaign according to ISO 9614-1 [3];
- free field pressure levels have been evaluated by taking into account divergence phenomena [4].

Maximum difference between measured and free field levels have to be (according to ISO 3745):

- $\pm 2,5$  dB for frequencies  $\leq 630$  Hz;
- $\pm 2,0$  dB for [800, 5000] Hz frequency range
- $\pm 3,0$  dB for frequencies  $\geq 6300$  Hz.



*Figure 2: measurement paths*

## **MEASUREMENT RESULTS**

Global linear measured levels and the free field ones are shown in Figures 3 and 4 relatively to each measurement path. Global linear difference is less than 2.5 dB for each measurement path. Global linear difference and differences relative to each frequency band are sometimes negative. This fact is absurd because experimental measured levels can't be less than free field ones [4]. Negative differences occur because noise source barycentre does not coincide with the room floor centre; it is placed at an about 15 cm height from the floor. Thus, noise source may be assimilated to a dipole and destructive interferences may cause level reductions [5].

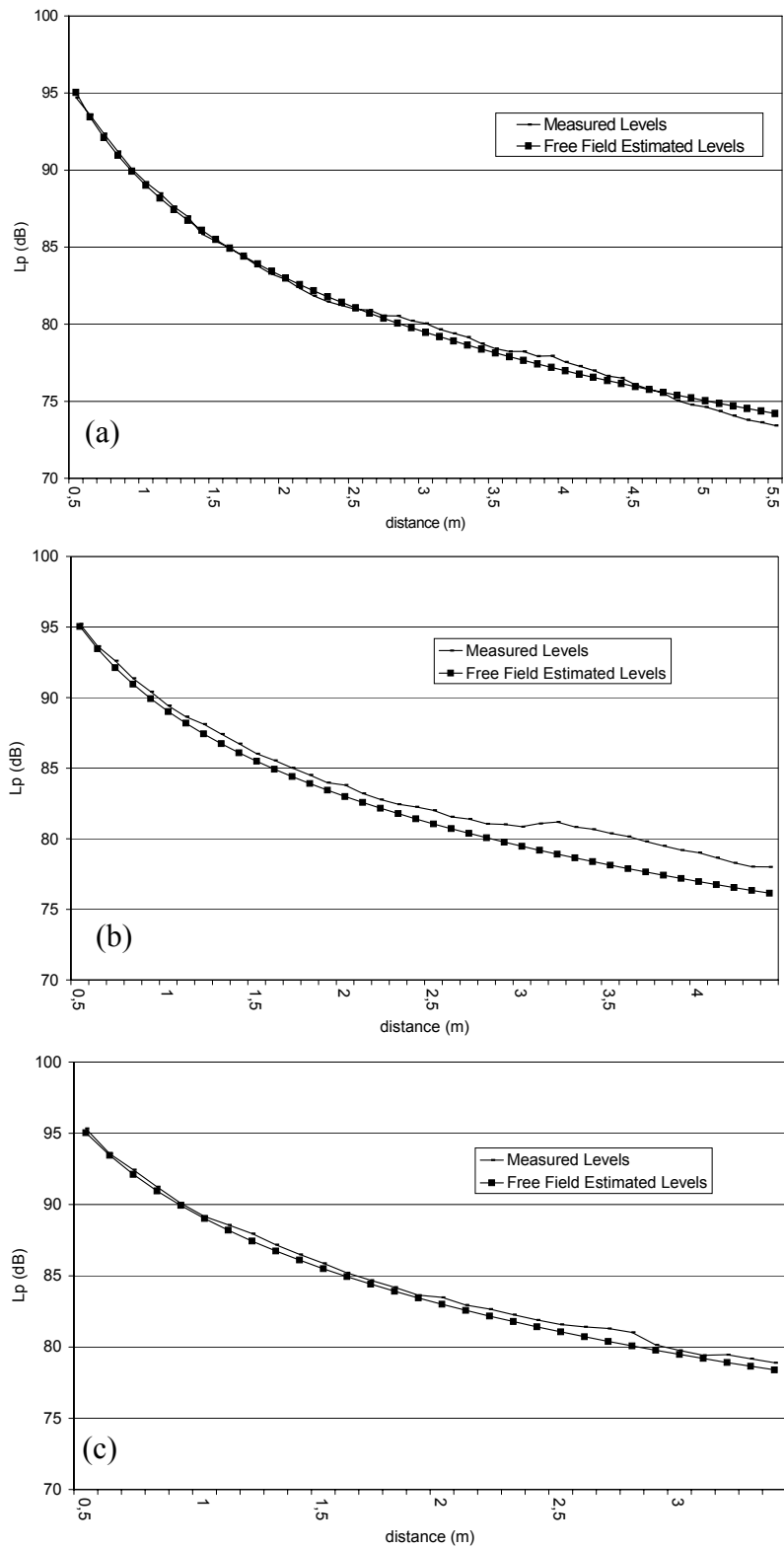


Figure 3: global linear measured level and free field level vs source-point distance relative to (a) path 1; (b) path 2; (c) path 3

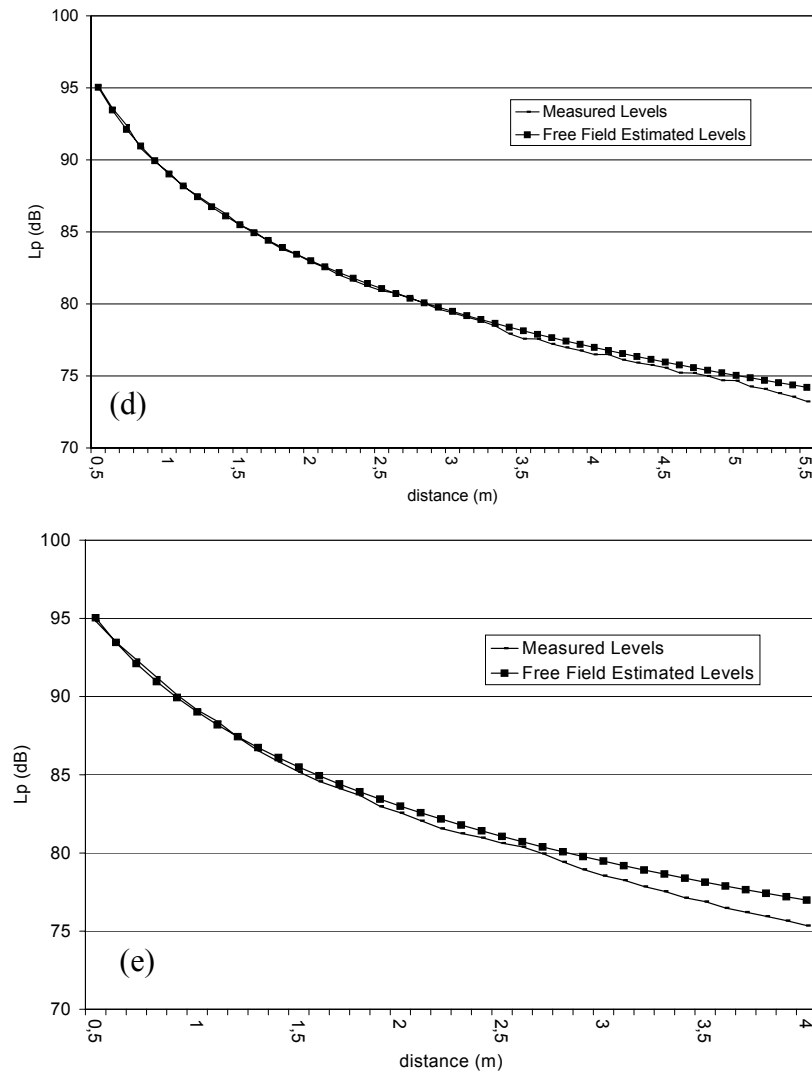


Figure 4: global linear measured level and free field level vs source-point distance relative to: (d) path 4; (e) path 5

ISO 3745 conditions are verified within a source-centred hemispheric surface. The hemispheric surface ray value is reported in Table 2 for each one-third octave frequency band.

ISO 3745 conditions are verified for the following frequency range and source-point distances values:

- within 3,3 m source-point distance and for frequencies  $\geq 315$  Hz relatively to path 1;
- within 3,0 m source-point distance and for frequencies  $\geq 315$  Hz relatively to path 2;

- within 2,5 m source-point distance and for frequencies  $\geq 315$  Hz relatively to path 3;
- within 3,3 m source-point distance and for frequencies  $\geq 315$  Hz relatively to path 4;
- within 2,7 m source-point distance and for frequencies  $\geq 315$  Hz relatively to path 5.

*Table 2: hemispheric surface ray value which verifies the ISO 3745 conditions*

<i>Frequency (Hz)</i>	<i>Hemispheric surface ray (m)</i>
12,5	0,5
16	-
20	0,5
25	0,7
31,5	0,5
40	1,2
50	1,3
63	0,6
80	0,8
100	0,6
125	0,7
160	0,5
200	1,1
250	0,8
315	2,5
400	2,8
500	2,7
630	2,6
800	2,5
1 K	2,5
1,25 K	2,7
1,6 K	2,5
2 K	2,8
2,5 K	2,7
3,15 K	2,5
4 K	2,6
5 K	2,8
6,3 K	2,5
8 K	3,3
10 K	2,7
12,5 K	2,7
16 K	2,6
20 K	2,5

## CONCLUSIONS

Acoustics characteristics of an hemianechoic room for electromagnetic compatibility tests have been investigated. The investigated room is coated by absorbing cones coupled to ferrite tiles. A measurement campaign has been led according to ISO 3745. Sound pressure levels due to an omni directional white noise source have been measured along five paths. The comparison between measured levels and free field estimated levels has shown that the investigated room is an acoustic hemianechoic room for:

- frequencies  $\geq 315$  Hz;
- within a 2,5 m radius source-centred hemispherical surface.

An acoustic hemianechoic room with the same dimensions of the investigated room generally accords to ISO 3745 for 80 Hz-20kHz frequency range [6]. The proposed research demonstrates that an anechoic room for electromagnetic compatibility test may be used as an acoustic anechoic room only over 315 Hz.

## REFERENCES

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