

Study to Determine the Sound Absorption Coefficient for a New Masonry Paint Under Development.

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Abstract

The acoustic attenuation capability from a material, it's indicated by the sound absorption coefficient, thus, this magnitude is of utmost importance to determinate which coating materials should be utilized in acoustic project. In this regard, it is possible to evaluate the performance of materials with acoustic features, enhance the attenuation at specific frequency bands, or assist in the development of new technologies in absorption, it becomes necessary to use techniques to determine the coefficient of sound absorption, via transfer function, according to standard ISO10534-2. The objective of this paper is to apply the specified standard and determine the sound absorption in masonry walls coated with a special paint, and the paint used is a new material under development with acoustic properties in noise reduction. The results are compared with other forms of coating normally used in Brazilian construction that are commonly commercialized.

Keywords: Noise, absorption coefficient, impedance tube, coated materials, noise absorption materials.

1. INTRODUCTION

Noise is defined as any kind of sound identity may be or not known, it's unpleasant and disturbing. Most of these noises can be very harmful to human beings, thus noise reduction becomes interesting to scientific society. The sound absorption is one of various methods to reduce noise, and most of its efforts aims to new kinds of sound absorption materials which in a near future could be commercialized and bring several benefits to human kind. Through this definition this paper has the objective to study the absorption coefficient of a new material that is under development on a paint factory. This material was available for the Universidade Federal de Uberlândia (UFU) for research proposes and to provide a report of product quality, so further this material can be commercialized in Brazil.

The sound absorption coefficient, α determinates the acoustic characteristics of different materials that are defined due to the ratio of absorbed acoustics energy and the incident acoustic energy. The α value depends on the incident sound frequency, material density, thickness and its own structure and it can vary between 0,0 to 1,0 (Gerges, 2000).

2. METHODOLOGY

Basically there are two methods to determinate sound absorption coefficient from materials using impedance tube: the classic analogic method; and the digital method (Gerges, 2000).

The determination of sound absorption coefficient using digital method is about 20 to 30 times faster and it covers a substantially continuous frequency band, while the classic analogic method sound absorption coefficient was obtained for discrete frequencies (Gerges, 2000).

Using the digital method with white noise, a noise with a constant distribution frequency is generated, and the sound pressure inside the tube is determined by two microphones in a predetermined position. The signals from microphones are processed simultaneously by a digital analyzer and sound absorption curve graph is generated due to frequency-dependency.

Although, there is another technique that uses a single microphone. The procedure of tube excitement with white noise can be considered stationary, therefore, the microphones signals doesn't need to be processed simultaneously. This way only one microphone can be used to perform signal acquisition at more than one distinct position along the tube, eliminating the procedure of calibration between two microphones, errors associated with phase difference from each microphone and computational difficulties.

Such system for measuring sound absorption coefficient is showed Figure 1, in which there is a microphone, a data acquisition device (DAQ) connected to a notebook with an installed a software developed in LabVIEW, a signal generator that generates white noise which is amplified and connected to a loudspeaker that is at one end of the tube.

To determine sound absorption coefficient it's necessary to find the value of the transfer function between signals obtained at position F (Far) and at position N (Near) according to figure 1, respectively.

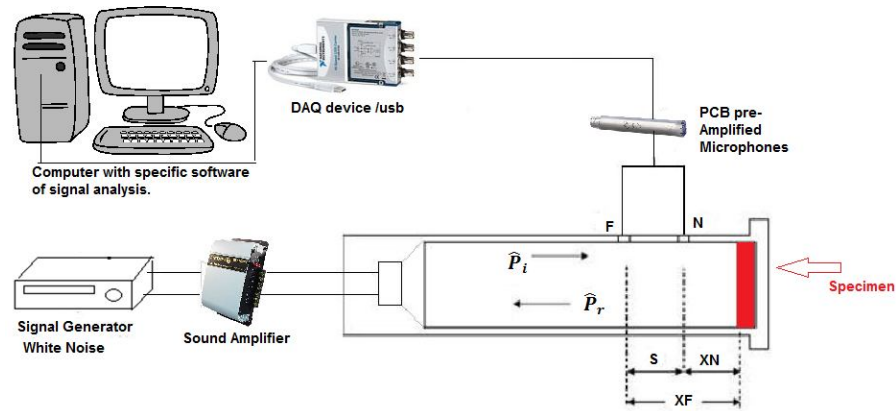


Figure 1. Connection diagram for the equipment's used on the impedance tube experiments.

The sound absorption coefficient is given by (Chu, 1986):

$$\alpha = 1 - \left| \frac{H_{FN} - e^{-iks}}{e^{iks} - H_{FN}} \right|^2 \quad (1)$$

Another important parameter is the NRC (Noise Reduction Coefficient) which can be defined as the arithmetic average of the sound absorption coefficients of the octave bands 250-2000 Hz:

$$NRC = \frac{1}{4} (\alpha(250) + \alpha(500) + \alpha(1000) + \alpha(2000)) \quad (3)$$

3. IMPEDANCE TUBE

For the construction of the impedance tube it was used the standard ISO 10534-2. The tube dimensions are presented at Figure 2. The material used for construction is acrylic.

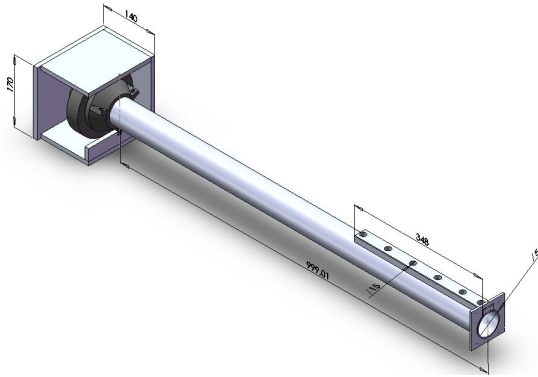
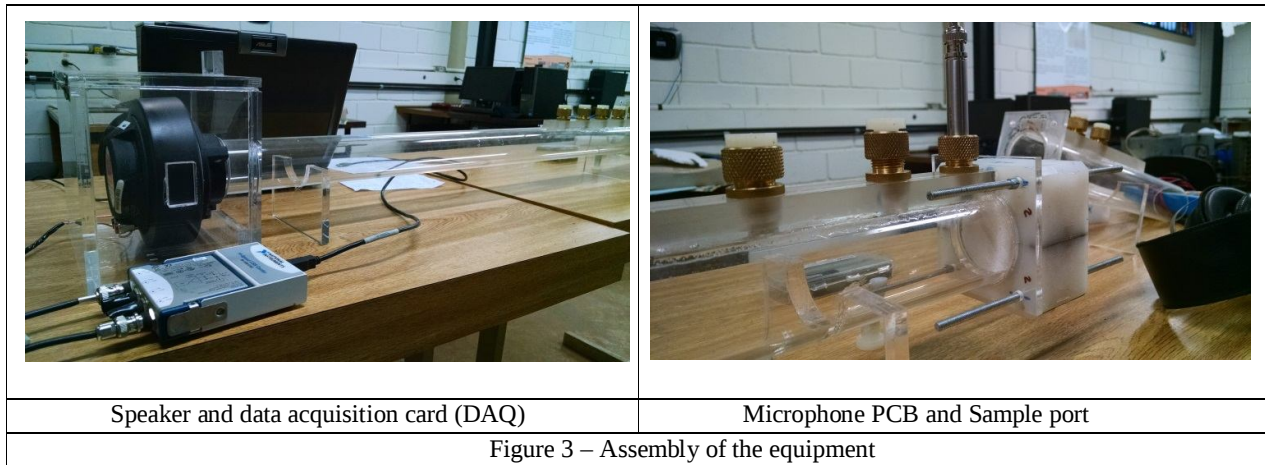


Figure 2. Impedance tube with dimensions in millimeters.

It is observed in Figure 2 on the left a loudspeaker, model JBL2426H positioned inside an acrylic box, on the right of the figure are the holes for placement of microphones and sample port by the end of the tube. For acquisition of sound pressure it was used a pre-amplified microphone PCB of 1/2" model 377B02, with the frequency range from 5 to 10000Hz, and data acquisition device from National Instruments model NI USB-9162. Figure 3 it has the assembly of equipment.]



It is noteworthy that the sound pressure is often collected acquisition in 8192 Hz and 8192 points, with a resolution of 1 Hz.

Finally, in Figure 4 there are the two samples under study



Figure 4. At the left of the figure is the specimen without paint and at the right is the specimen with paint.

4. RESULTS AND ANALYSIS

Limitations due to geometry

Based on the methodology adopted, the impedance tube has a cutoff frequency for propagating plane waves. According to Equation (3) this frequency depends on the duct diameter, so the Table (1) shows the diameter and the cutoff frequency of the tube under study.

Table 1 – Cutoff frequency of the impedance tube.

Tube Internal Diameter [mm]	Cutoff Frequency [Hz]
52	3840

Therefore, the absorption coefficient can be calculated by the frequency of 3840 Hz, since above this frequency will have high-order modes, which hinders the calculation of the absorption coefficient according to methodology proposed in standard ISO 10534-2.

Still regarding the geometry of the apparatus, there is the distance between the points of positioning of the microphones. According to studied equations there are minimum, maximum and optimum frequency, which are determined in relation to microphones disposal. At table (2) whether those frequencies are each distance.

Table 2. Minimum (f_{min}), maximum (f_{max}) and optimum (f_o) frequency, depending on the distance between microphones.

Test	s [mm]	f_{min} [Hz]	f_{max} [Hz]	f_o [Hz]
1	49	348	2784	1740
2	116	147	1176	735
3	183	93	745	466
4	251	68	543	340
5	318	54	429	268
6	67	254	2036	1272
7	137	124	996	622
8	202	84	675	422
9	269	63	507	317

It is seen that despite the various configurations of the distance between microphones, one can evaluate the sound absorption coefficient of the frequency range 54 to 2784 Hz. Thus, the option is to present results only for tests 1 and 5.

It is observed that the absorption coefficient in the presence of the paint has a gain in the frequency range of operation. For the purpose of comparison it is shown in Table 3 the NRC coefficients for both situations

Table 3 – Sound absorption coefficient and NRC for specimen with and without paint.

	250 Hz	500 Hz	1000 Hz	2000 Hz	NRC
without Paint	0,37	0,19	0,13	0,12	0,20
with Paint	0,44	0,20	0,13	0,27	0,26

It is noted that the NRC with paint is 30% greater than the NRC without paint, which has highest values of sound absorption coefficient at 250 Hz and 2000 Hz yet in conjunction with graphic results analysis, it was observed that for high frequencies sound absorption of the specimen with paint is higher than without paint, which corroborates the NRC obtained. However, for reliable values of acoustic absorption in higher frequencies with other apparatus and other geometric constraints, it has a higher cutting frequency (near 8000 Hz) and the distance between microphones reliability at high frequencies is required.

5. CONCLUSIONS

Based on the developed paper concludes that:

- The impedance tube has limitations due to their geometry as:
 - o The internal diameter - limits the cutoff frequency for the presence of plane waves;
 - o The distance between holes - determine the minimum, maximum and ideal for acquisition of sound pressure frequency.
- The calculation of sound absorption coefficient and the NRC glass wool showed values of around 0.9, as expected due to its high sound absorption. Validating thereby the experimental apparatus.
- It was noted that throughout frequency spectrum the sound absorption coefficient for specimen with paint is higher than specimen without paint. The specimen with paint the NRC is about 30% higher than without paint therefore useful in sound absorption.
- For reliable analysis at high frequencies suggest another tube impedance with cutoff frequency near 8000 Hz and distance between microphones for reliability purchase this frequency range.

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