

## Projeto e construção de um tubo de impedância para a caracterização das propriedades acústicas de materiais porosos

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### Abstract

In the present project, it was intended to design and build a low-cost impedance tube so as to characterize the acoustical properties of materials. The tube was designed and built at the Computational Mechanical Engineering (DMC) of the Faculty of Mechanical Engineering (FEM) of UNICAMP, in order to have maximum diameter of 28 mm, not only to enable the analysis of small dimension samples, but also to enable the experimentation in frequency bands with superior limit near 6000 Hz.

### Key words:

Acoustics, Impedance tube.

### Introduction

Investigation of different topics related to acoustics and vibration of mechanical systems has been conducted at the Computational Mechanical Engineering (DMC) of the School of Mechanical Engineering (FEM) of UNICAMP. Among them, there is the investigation of new materials and structures which require experimental characterization of its properties, so as to improve acoustic comfort. Generally, the utilized methods to investigate the material properties encompass the experimental determination of the acoustical absorption and reflection coefficient as well as the transmission loss, as a function of the frequency, through an impedance tube as shown in Figure 1.

There are currently available at the DMC a few impedance tubes with varied diameter sizes and lengths, among which, the smallest diameter is 60 mm for tests in frequencies from 125 to 2500 Hz. Thus, it was intended in this project to design and build an impedance tube in order to have maximum diameter of 28 mm, not only to enable the analysis of small dimension samples, but also to enable the experimentation in frequency bands with superior limit near 6000 Hz.

### Results and Discussion

Both the standing wave ratio method and the transfer function method are utilized for obtaining the acoustic absorption and reflection through the assembly shown in Figure 1(a), and are normalized by BS EN ISO 10534-1:2001, ISO 10534-2:2001, ASTM C 384-04 and ASTM E 1050-12. Whereas the four microphone method is utilized for obtaining the sound transmission loss through the assembly shown in Figure 1(b) and is normalized by ASTM E2611-09.

The previously referred norms indicate specific relations that have to be followed to determine the dimensions of the tube, such as tube internal diameter, which is related to the desired maximum frequency, length, distance between microphones, distance between microphone and sample, and tube thickness. Additionally, there is also mentioned loudspeaker characteristics, amplitude of the signal, as well as general instructions, to guarantee measurement precision and other aspects.

The calculated dimensions were: both principal tube and anechoic termination, 500 mm, the distance between

microphones, 21 mm, sample holder, 150 mm, the distance between last microphone and sample, 28mm, the distance between the first microphone and the sample in the anechoic termination, 100mm.

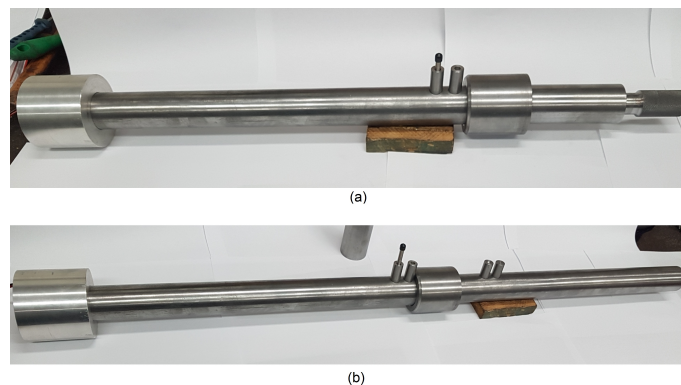


Figure 1. Impedance tube: (a) with the sample holder, (b) with the anechoic termination.

### Conclusions

The tube is currently in a final phase of construction, which means, the last details are being arranged. Owing to budget and instrumental limitations, the project had, many times, suffered variations from the original design, which is not yet completely resolved. The last step is to test the impedance tube with materials of known properties, and thus confirming the quality of the instrument.

### Acknowledgment

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<sup>1</sup> Norma BS EN ISO 10534 1: 2001, Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 1: Method using standing wave ratio.

<sup>2</sup> Norma BS EN ISO 10534 2: 2001, Acoustics – Determination of sound absorption coefficient and impedance in impedance tubes – Part 2: Transfer-function method.

<sup>3</sup> Norma ASTM E2611 – 09, Standard Test Method for Measurement of Normal Incidence Sound Transmission of Acoustical Materials Based on the Transfer Matrix Method.