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THE INFLUENCE OF SAMPLE SIZE ON THE RESULTS OF SOUND INSULATION MEASUREMENT CONDUCTED IN SMALL COUPLED REVERBERATION ROOMS

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ABSTRACT

The paper presents the results of acoustic insulation measurements conducted in a unique small size coupled reverberation rooms. The volumes of the rooms are approximately 1.36 m³ each, which imply a lower measurement range limit of 400 Hz for the actual dimensions of the samples (and 50 Hz for 1:8 scale testing). Aim of the research was to evaluate the measurement setup and assess its suitability for studying the properties of various types of material including metamaterials. The influence of sample size and geometry on measurement outcomes was analyzed by comparing four square windows of side lengths equal 8.5, 17.5 cm, 35 cm and round 65 cm, and two rectangular windows of dimensions equal 12.5 × 25 cm and 25 × 50 cm. Five samples of different materials with various thicknesses selected to have diverse properties affecting wave propagation were studied: steel 0.6 and 1 mm thick, PMMA 3.8 mm thick, MDF 3.2 mm thick, Sylomer (HD 100) 12.5 mm thick and gypsum board 12.5 mm thick were measured. The analysis showed that the influence of the size and shape of the window on the obtained insulation coefficient dependent on the test frequency and the stiffness of the sample material.

Keywords: *sound insulation, small sized coupled reverberation rooms, acoustic insulation measurements, sample geometry*

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1. INTRODUCTION

In laboratory acoustic testing of the sound insulation properties of materials and structures, three standardized methods can be used [1]. The first involves measuring the sound reduction index (R) of a sample placed between two reverberation rooms. The second method also uses the sound reduction index (R), where the sample separates a source room with a free-field condition from a receiving room with a reverberant field. The third approach is based on the measurement of transmission loss (TL) in an impedance tube. The article focuses on the research of the sound reduction index (R) using coupled reverberation rooms.

The measurement of the sound reduction index (R) using coupled reverberation rooms is described in the ISO 10140 series of standards, from part 1 to part 5. For material testing in full size reverberation rooms, the standard requires the use of a sample with a surface area of 10 m². Various methods of mounting the sample and sealing are also recommended [2]. In the literature, there is little information on the influence of sample size and shape on the results obtained. Wareing et al. demonstrated that sample size can significantly affect sound transmission loss, depending on the construction of the tested element [3]. In a subsequent study, the authors observed that smaller samples exhibited higher sound transmission loss at frequencies below the coincidence frequency [4]. On the other hand, study made by Mleczko remarked that small baffles have lower sound insulation compared to the large baffle [5]. The differences noted are more significant in the case of the square-shaped baffle. However, the author himself points out that the study should be expanded with more samples and repetitions. Therefore, the aim of this study is to address the gap in the literature by examining how different sample sizes and shapes affect the sound reduction index measured in small size coupled reverberation rooms.

2. METHODS

The tests were performed on a unique small size coupled reverberation room [6, 7]. The stand consists of two reverberation rooms, each with a volume of 1.36 m³, designed as irregular hexagonal enclosures constructed from 20 mm thick plexiglass panels. The stand is a 1:8 scale of the coupled reverberation rooms located at AGH University of Science and Technology [8]. The rooms are connected by a shared wall that includes measurement windows for mounting test samples. The dimensions of the windows and corresponding measurement samples are summarized in Table 1.

Table 1. Measurement windows and samples shape and size.

Sample No.	Sample Shape	Sample Size [cm]
1	square	8.5 x 8.5
2	square	17.5 x 17.5
3	square	35.0 x 35.0
4	square	65.0 x 65.0
5	rectangular	12.5 × 25.0
6	rectangular	25.0 × 50.0

For investigating the influence of sample size on sound insulation measurement results in smallcoupled reverberation rooms, a selection of materials was made to encompass a wide range of thicknesses, internal structures, and, most importantly, diverse properties affecting wave propagation. The tested materials included:

- Steel – thicknesses: 0.6 mm;
- Steel – thicknesses: 1.0 mm;
- PMMA (Polymethyl methacrylate) – thickness: 3.8 mm;
- MDF (Medium-density fibreboard) – thickness: 3.2 mm;
- Sylomer (HD 100) – thickness: 12.5 mm;
- Gypsum board – thickness: 12.5 mm.

The sound reduction index (R) was measured in accordance with ISO 10140-4 [2] within the frequency range of 400–20,000 Hz. The test sample was mounted in the measurement window, securely pressed against the frame, and sealed with putty to prevent leakage.

3. RESULTS

This section presents the results of sound reduction index (R) measurements conducted for samples of various sizes and shapes. The aim was to evaluate how these parameters influence the measured acoustic insulation performance. Selected data sets are shown to illustrate the observed trends and differences. The full dataset was analyzed for consistency and repeatability across repeated measurements.

Each sample was measured three times. For each repetition, the sample was removed and reinserted into the measurement opening, then carefully resealed with putty. As part of the study, all results were compiled for each measurement opening and for each sample material across different opening sizes.

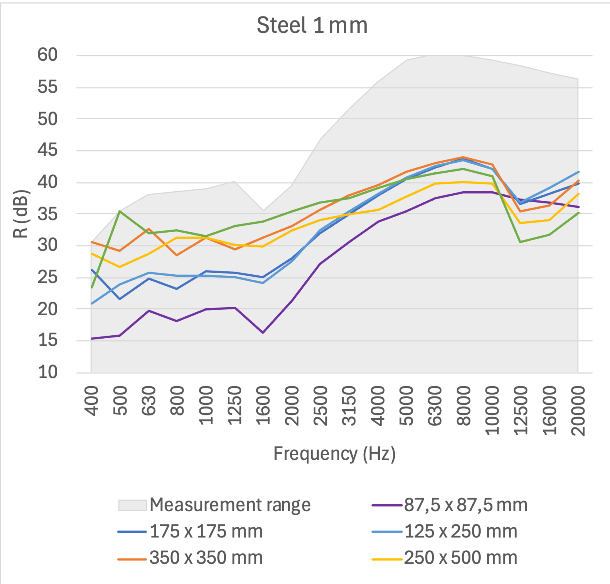

Figure 1. Sound reduction index (R) measured for a 1 mm thick steel sample of various shapes and sizes: 8.5 cm × 8.5 cm, 17.5 cm × 17.5 cm, 35cm × 35 cm, 65 cm × 65 cm, 12.5 cm × 25 cm and 25 cm × 50 cm.

This article presents selected sets of the test results. Figure 1 shows sound reduction index (R) measured for a 1 mm thick steel sample of various shapes and size.

The analysis of the sound reduction index (R) for steel samples with a thickness of 1 mm, tested in openings of varying sizes, revealed a significant influence of sample size on the measurement results. Above the coincidence frequency, an increase in sample size corresponds to a decrease in R, whereas below this frequency, larger samples exhibit higher R values. A similar trend was observed for the other tested materials, including steel samples with a thickness of 0.6 mm, PMMA with a thickness of 3.8 mm, MDF with a thickness of 3.2 mm, Sylomer HD 100 with a thickness of 12.5 mm, and gypsum board with a thickness of 12.5 mm. For clarity and conciseness, the results and analysis presented here are based on the 1 mm steel samples as a representative example.

4. CONCLUSIONS

The study demonstrated that the influence of window size and shape on the measured sound reduction index depends both on the test frequency and the stiffness of the sample material. In the case of the steel samples, a clear correlation was observed between sample size and R values, with the direction of this effect varying depending on whether the frequency was above or below the coincidence frequency.

These findings are more consistent with the observations made by Mleczko [5], who reported lower sound insulation for smaller baffles, particularly in square configurations. In contrast, the results diverge from those reported by Wareing et al. [4], especially in the context of frequencies below the coincidence frequency. This suggests that the relationship between sample size and sound insulation may be more complex than theoretical assumptions typically indicate and is likely influenced by factors such as boundary conditions and panel stiffness.

5. ACKNOWLEDGMENTS

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