DOI: 10.61782/fa.2025.0494

FORUM ACUSTICUM EURONOISE 2025

INVESTIGATING POSITIONAL EFFECTS OF THE PERIMETER FRAME IN SOUND ABSORPTION MEASUREMENTS

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ABSTRACT

When measuring the sound absorption coefficient according to ISO 354:2003, the standard commonly requires the use of a reflective frame around the perimeter of the test specimen, to keep the edges from absorbing sound. Logically, this is most important at high and medium frequencies, but previous studies have shown a significant impact also at lower frequencies. At this end of the spectrum, the frame seems to have a positive effect on the measurement results – an effect that persists even when the test specimen is only partially covered by a frame. To get closer to the cause of this phenomenon, reverberation room measurements have been carried out on a partially framed test specimen. Several different configurations of a partial frame have been tested, with a view to observe whether the position of the partial frame relative to the test specimen is of any importance to the measurement results. The results from these measurements are presented and discussed in this paper.

Keywords: *sound absorption measurements, reverberation room, measurement setup, edge effects*

1. INTRODUCTION

In annex B in the standard for measuring the sound absorption coefficient in a reverberation room, ISO 354:2003, rules and guidelines for mounting of different types of sound absorbers are given [1]. Most commonly, sound absorbers are placed directly on the floor during testing, for which the standard normally requires a reflective frame to be built around the perimeter of the test specimen to keep the edges from absorbing sound. However, previous studies have shown that the presence of a frame has a significant positive impact on the measured sound absorption coefficient at the lowest frequencies [2], an impact that seems to be dependent on the placement of the test specimen and its perimeter frame in the reverberation room [3]. To look deeper into this phenomenon, further reverberation room measurements have been carried out – this time with a focus on what happens when a test specimen is only partially covered by a frame.

2. METHODOLOGY

A test specimen of 200 mm melamine foam was used in the measurements. 15 pieces of 0.6 x 1.2 m was assembled into a test object of 3 x 3.6 m. This test specimen size fully complies with the requirements for test specimen size and shape given in ISO 354 when fully framed, however, the absorptive area is larger than 12 m^2 for most of the partially framed measurements.

For the frame, 48 x 195 mm spruce wood was used. Weights were used to keep the frame in place, avoiding air spaces between the frame and the test specimen, and the frame was sealed to the floor with tape. The frame is 5 mm lower than the test specimen, but this is not expected to affect the measurement results at lower frequencies. The test specimen was placed in the room as shown in Fig. 1, and the four parts of the frame named North, South, East and West (abbreviated N, S, E and W). In total, 16 tests were carried out, covering all possible frame combinations, see Tab. 1.

The reverberation room is 8 x 6.65 x 3.76 m, which gives a volume of exactly 200 m^3. It is equipped with 14 diffusers with a total area of 42 m^2. All tests were carried out with the interrupted noise method in accordance

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with ISO 354:2003, with three source positions, four microphone positions per source position and three measurements per microphone position. Ensemble averaging was used to evaluate the reverberation times with T_{20} used as evaluation range.

Finally, the results have been subject to a limited analysis in an attempt to discover any emerging patterns in the data. However, due to time and funding constraints, a deeper analysis is left for future work.

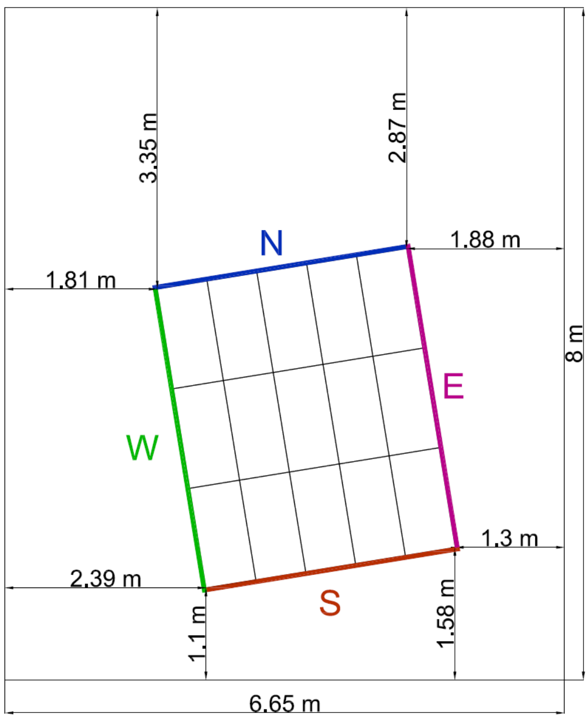

Figure 1. A horizontal view of the reverberation room, the placement of the test specimen and the names of the four parts of the frame.

3. RESULTS

All measurement results are presented, somewhat chaotically, in Fig. 2. The figure shows that between 100 and 160 Hz, the measurements with no frame and full frame act as outliers, with every other measurement inbetween the two. The standard deviation of all 16 measurements is plotted in Fig. 3. Because the low frequencies are the ones at interest, the remaining figures will be limited to the frequency range of 100–315 Hz for the sake of both author and readers.

Table 1. A list of the 16 tests, with frame configurations and exposed absorptive area.

Frame configuration	Exposed absorptive area
No frame	13.44 m^2
N	12.84 m^2
S	12.84 m^2
E	12.72 m^2
W	12.72 m^2
S+W	12.12 m^2
S+E	12.12 m^2
N+W	12.12 m^2
N+E	12.12 m^2
N+S	12.24 m^2
E+W	12.00 m^2
N+E+W	11.40 m^2
S+E+W	11.40 m^2
N+W+S	11.52 m^2
N+E+S	11.52 m^2
Full frame	10.80 m^2

In Fig. 4 the average of the measurement series with one piece of frame, two pieces of frame and three pieces of frame are plotted together with the measurements without frame and with a full frame. Then Fig. 5–Fig. 7 are showing the measurements with one piece of frame, two pieces of frame and three pieces of frame separately.

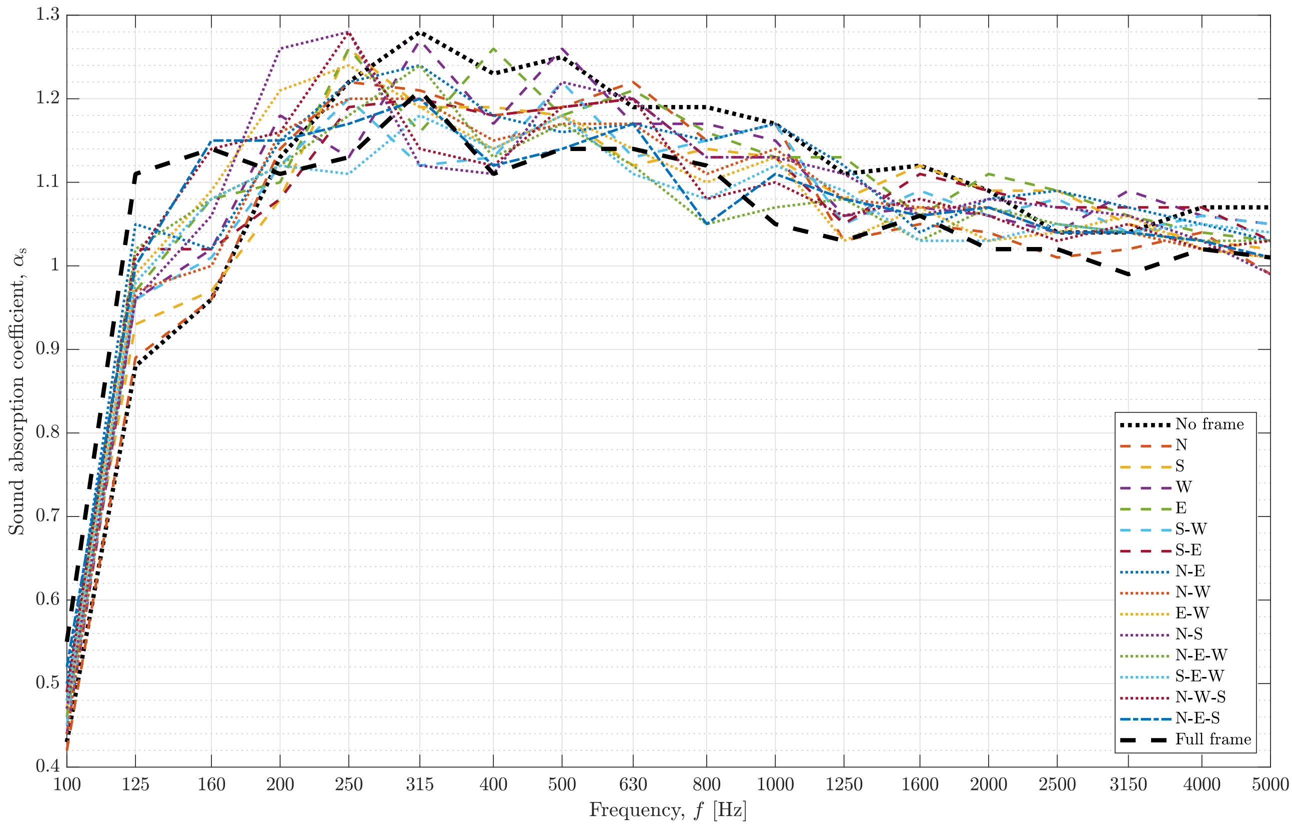

Figure 2. All measurement results as a function of frequency.

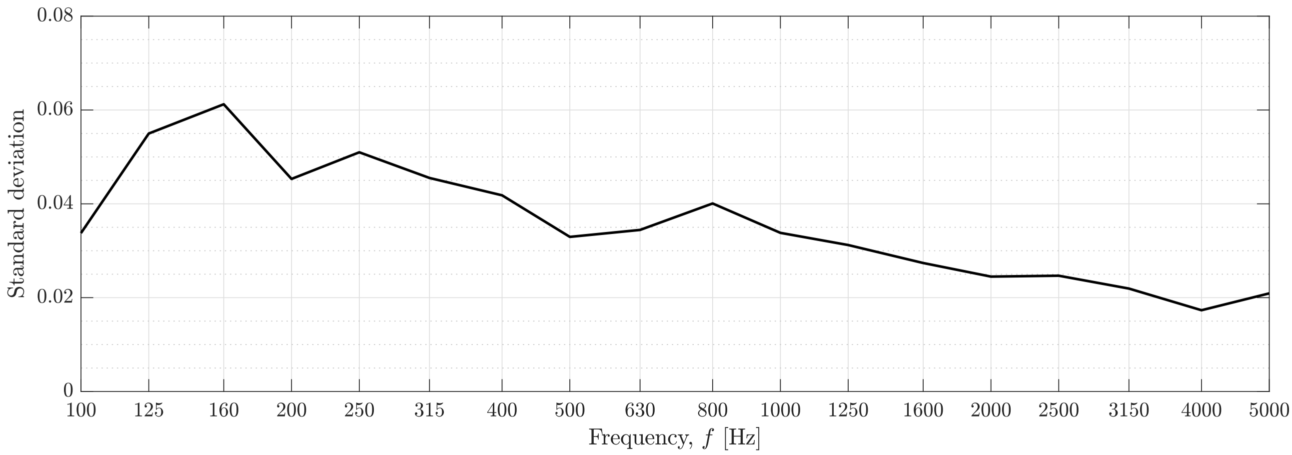

Figure 3. The standard deviation of the 16 measurement series.

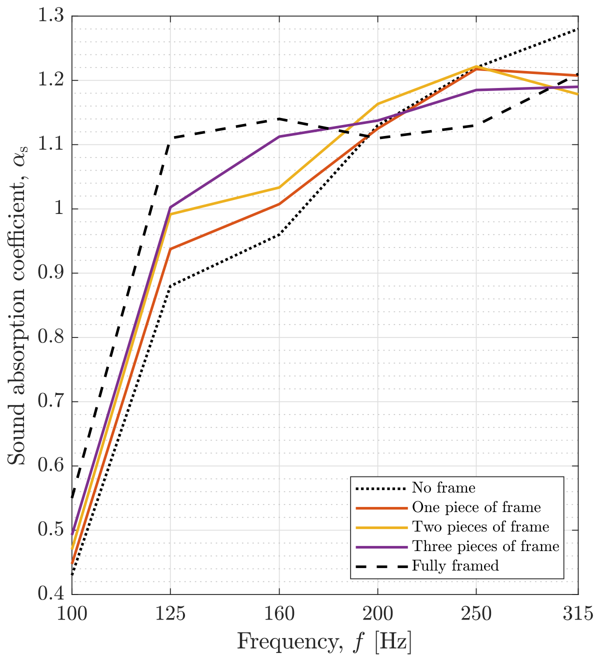

Figure 4. The average of the measurements with one, two and three pieces of frame

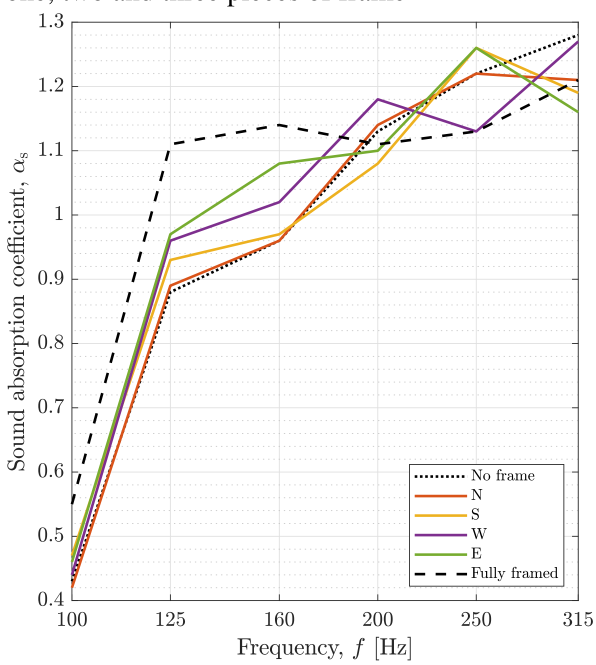

Figure 5. Measurement results with one piece of frame.

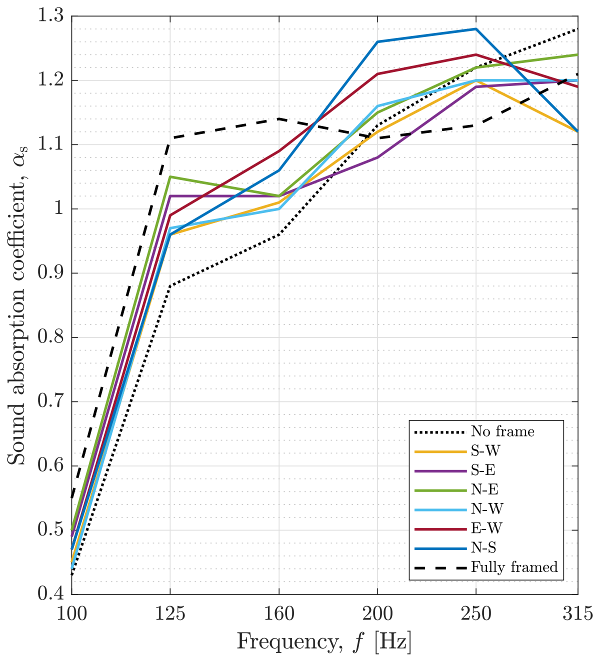

Figure 6. Measurement results with two pieces of frame.

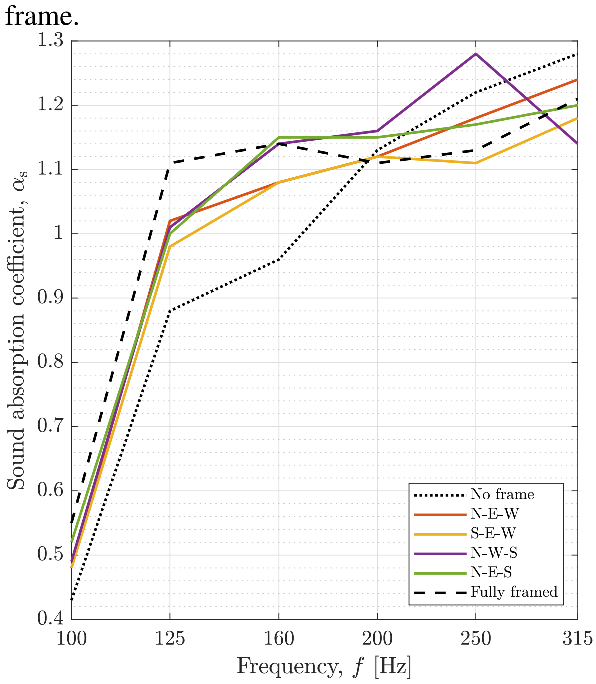

Figure 7. Measurement results with three pieces of frame.

4. DISCUSSION

The results clearly show that the frame has a positive impact on the results at lower frequencies, as seen in previous work. As shown in Fig. 4, when adding an additional piece of frame, the measured sound absorption coefficient increased at 100, 125 and 160 Hz. The difference between the measurements without a frame and with a full frame at these frequency bands were 0.12, 0.22 and 0.18 respectively, which correspond to increases of 28, 26 and 19 % from the worst to best result. At 200 Hz, the curves intersect. This is somewhat lower than in previous experiments [2, 3].

At frequencies above 160 Hz, there are also significant differences between the measurement series, but those differences are seemingly more chaotic, and the clear relationship between levels of framing and the measured sound absorption coefficient that is observed at the lowest frequencies is not observed here. In terms of positional effects, no simple relationship between the position of the frame and which frequencies are affected by its presence has been found. However, the Eastern frame seems to have a generally strong impact on the 125 Hz band, and it was present in all but one measurement series where the 125 Hz band was measured at or above 1. Similarly, it was present in all but one measurement series where the 160 Hz band was measured at or above 1.05. This will be subject to future investigation.

The far and away best result at 125 Hz was obtained with a fully framed test specimen. Similar results were seen at 100 Hz, but less dramatic, seeing as the sound absorption coefficient there were lower to begin with. At 160 Hz, however, the three pieced frame performed strongly, and two of those measurement series were on par with the fully framed one. At 200 and 250 Hz, several partial frame configurations performed better than the fully framed one.

A fascinating observation was that when averaging the results in every third octave band across a measurement series, all measurement series had an average sound absorption coefficient between 1.05 and 1.085. The standard deviation of this average was much lower than in any single third octave band. This points in the direction of randomness playing a significant part in the deviations seen above 160 Hz.

5. FURTHER WORK

The measurement data will lay the foundations for deeper investigations. There are many intriguing tendencies in the dataset, which will be interesting to look at in further detail.

6. CONCLUSION

Reverberation room measurements of sound absorption have been carried out in order to further investigate the positional effects of the frame around a test specimen. The measurement results have shown a clear positive impact from the frame at the lowest frequencies – an impact that at the three lowest third octave bands can be observed to an increasing degree as the test specimen goes from unframed via partially framed to fully framed. The highest standard deviations were found at 125 and 160 Hz, but when accounting for the lower sound absorption coefficient, the 100 Hz band is also significantly affected.

No simple relationship between frame configuration and what frequency bands are affected has been found at the time of writing, and a deeper analysis of the measurement data will be carried out in future work.

7. ACKNOWLEDGMENTS

The measurements covered in this paper has largely been carried out outside of the author's working hours. The work with the paper itself has been funded by the Construction Technology group at SINTEF Community, led by Monica Strøm Nodland. I would like to thank Monica for her support.

8. REFERENCES

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