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Acoustic attenuators for aggressive environments

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ABSTRACT

Alara-Lukagro has conducted research on the essence of acoustic attenuators and in recent years on the possibility to create broadband attenuators without absorbing materials. This could be done using friction of the acoustic wave. An experimental setup using micro-perforates shows how the potential attenuation of systems without absorbing material relates to attenuators with absorbing materials, quantitatively, for both broadband attenuation, flow generated noise and friction losses. The results will be presented, the principles explained and the potential quantified.

Keywords: Attenuator, Insertion loss

1. INTRODUCTION

In noise control, one of the most interesting challenges lies in the combination of providing Sound insulation whilst maintaining a significant opening for ventilation. In some industries the gasses are so aggressive, hot, or sticky that splitter attenuators don't provide a sustainable solution. If the sound source is broadband or variable or there is no absorption near the source, resonance attenuators can't be made to fit the noise spectrum.

In theory the edge of a splitter attenuator still will hold its pressure drop properties. Therefore it was decided to quantify the transmission loss of splitter attenuators without wool and micro-perforated plates.

Because the outcome of this research is classified the geometries that were tested are not included in this paper, but test results are. However the comparison with historical lab tests and simulations on splitter silencers is. In this way the phenomena can still be quantified and a prove of concept can be provided..

2. Test setup

The test was conducted at the test facility of Alara-Lukagro, which is at the same site as the production facility. As a result some test had to be carried out after working hours. The tests were all conducted in accordance with ISO 7235; 2003. The measurements were all done in threefold, which include a scan of the source surface, a measurement at a certain distance and an average sound pressure level in a reverberant room. The source was placed inside a thick steel casing with a big ventilator on the roof. When the ventilator was not in operation, the opening was closed by an absorbing sandwich panel. The channel leading from the casing to the reverberant receiving room was equipped with an inline silencer half way.

For each setup reverberation times of the receiving room were re-evaluated. The reverberant sound pressure level, SPL difference between measurements with and without silencer was corrected for the change in reverberation time T:

$$D = SPL_0 - SPL_1 + 10 \cdot \log\left(\frac{T_0}{T_1}\right) \quad (1)$$

Note that the reverberation time of a reverberant room with an open channel is typically lower than for rooms with a partially open channel. Reverberation times can show strong inconsistencies in the lower frequencies. In this analytics we obtain a series of reverberation times in different open areas.

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If linear functions are made to fit the reverberation time to the open area for each series of identical elements, a fictive reverberation time can be obtained that suffers less deviations in the lower frequencies. The fictive reverberation time:

$$T_f = T_{av,oa_{av}} + (oa - oa_{av}) \cdot \frac{\sum \delta T_{av}}{\sum \delta oa_{av}} \quad (2)$$

Where oa is open area and av means average.

The reverberant measurements can now be evaluated in two ways. Where in one way the reverberation time suffers less inconsistencies, so only strong deviations in the average sound pressure level have a strong effect. In te other way the reverberation time and the average sound pressure level have a strong effect on the deviations, but they are both actually measurement.

ISO 7235 (1) doesn't state which evaluation method should be preferred. Of the four attenuation values two are derived from the average sound pressure level in the reverberant room. That average sound pressure in the reverberation room doesn't suffer as much from manual inconsistencies, or not properly evaluating standing waves due to the singularity of the position, as the other two attenuation values. Therefore it can be allowed to weigh all four measurements equally and obtain a standard deviation, which tells something about the accuracy of the measurement.

3. Results

3.1 Insertion loss

Two types of micro perforated attenuators were evaluated with different variations within each type. One variation is the relative open area. In figure 1 and 2 the resulting insertion loss of type 1 and 2 is plotted per 1/3rd octave band for different open areas.

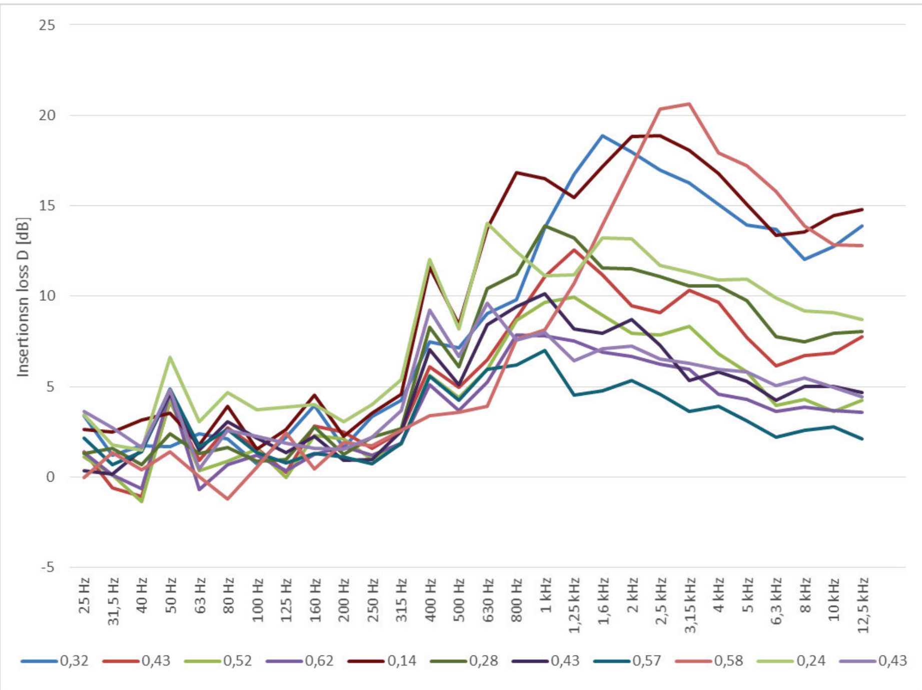

Figure 1 - Insertion loss micro-perforated attenuator type 1

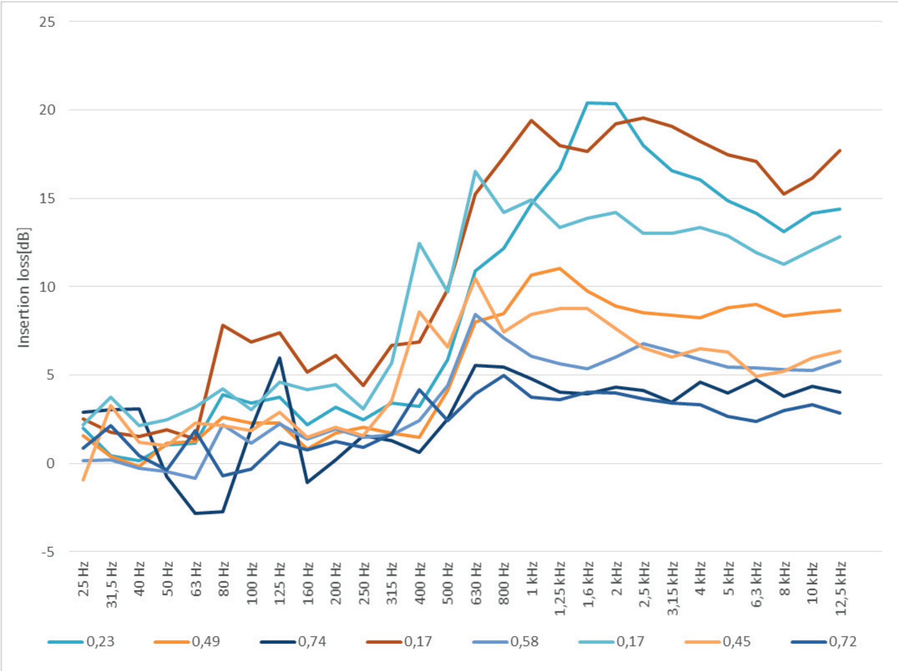

Figure 2 - Insertion loss micro-perforated attenuator type 2

The results are still inhomogeneous, therefore it is good to be aware of the standard deviation of these results. The standard deviation is given in figure 3 and 4.

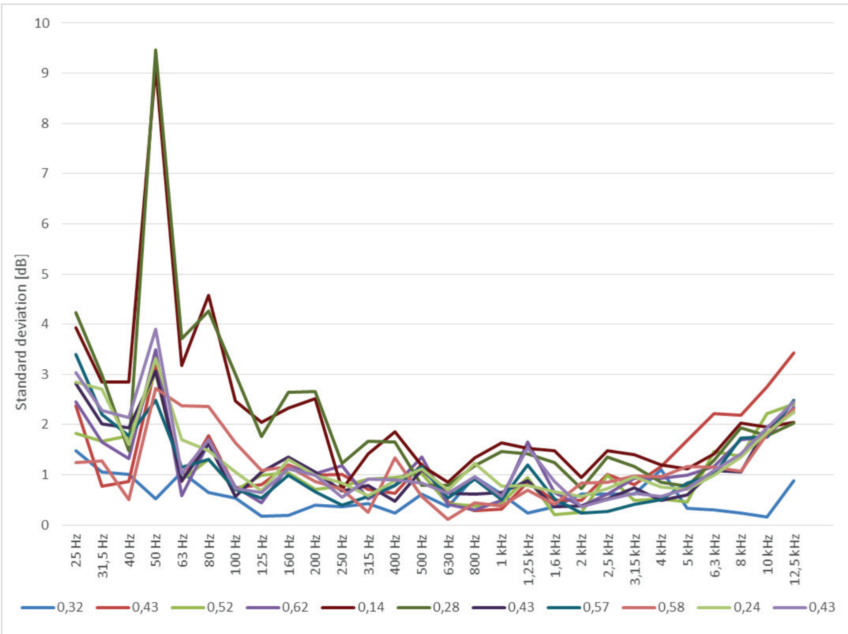

Figure 3 - Standard deviation for type 1 results

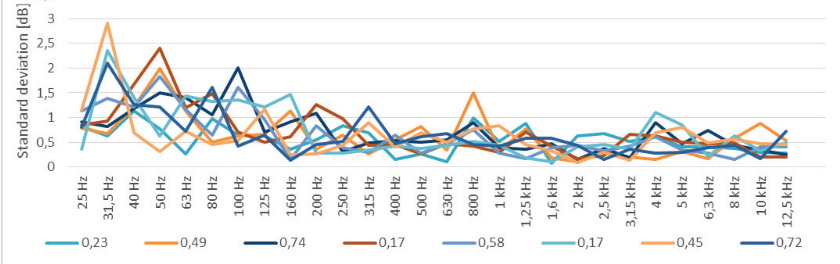

Figure 4 - Standard deviation for type 2 results

The insertion loss are reasonable from 400 Hz and above. The insertion loss is especially good and reliable between 2 and 5 kHz. The insertion loss of attenuators with a wool filling is significantly higher, see figure 5 and 6.

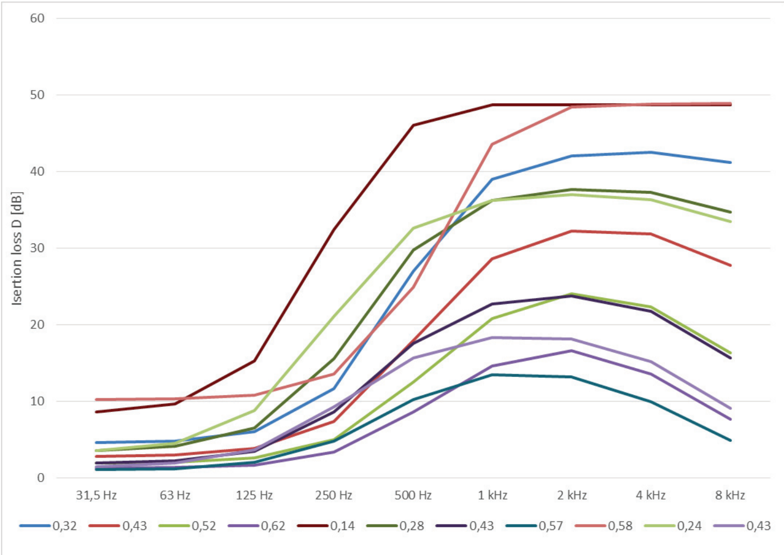

Figure 5 - Insertion loss for attenuators comparable to type 1 with wool infill

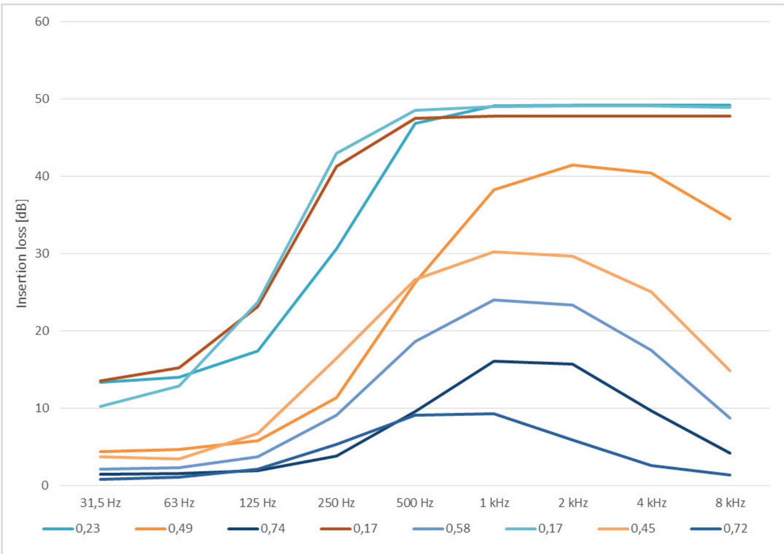

Figure 6 - Insertion loss for attenuators comparable to type 2 with wool infill

The insertion loss of attenuator with infill is around three times better than for attenuators without infill. Nonetheless this shows that the pressure drop is a real useable mechanism. Note that both attenuators use the same principles of transferring acoustic (kinetic) energy into a heat difference.

Another way to protect the wool is to use a protective foil layer. These foil layers have a much stronger negative influence in the higher frequencies. In figure 7 the insertion loss is compared of two attenuators with and without a protective layer. These tests were done without inline silencer, so there is a strong phase-shift in the lower frequencies and the low frequency insertion loss varies strongly, and the low frequency insertion loss values are unreliable.

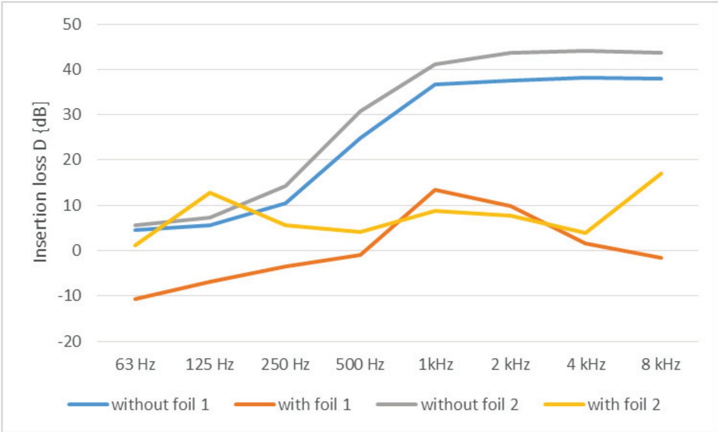

Figure 7 - Insertion loss with and without foil

In figure 8 we see that the performance from around 2 kHz and higher is significantly better for the micro-perforates compared to attenuators with infill than for attenuators with foil compared to attenuators without foil.

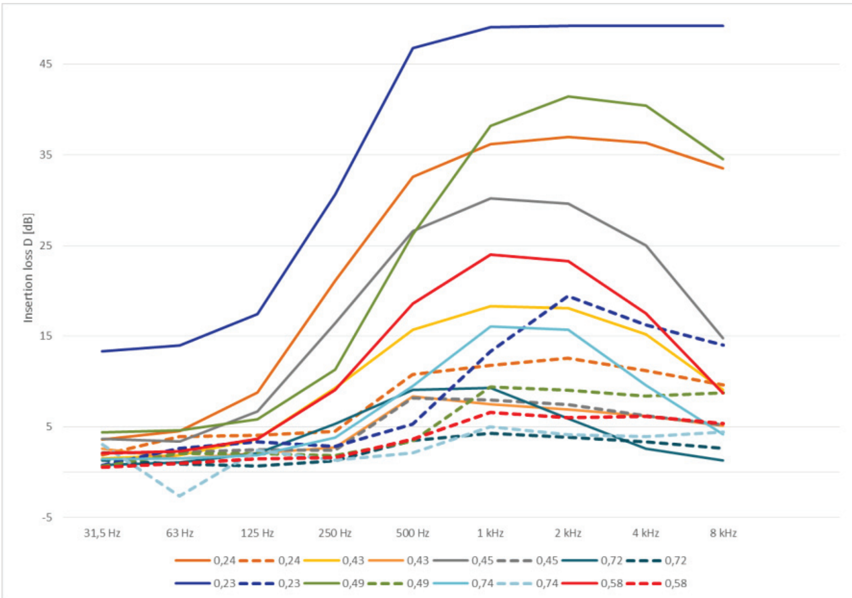

Figure 8 - Insertion loss with and without wool

The currently tested attenuators with micro-perforates show good performance above 2 kHz and reasonable performance above 400 Hz. For lower frequency performance some interesting trends were observed that require further investigation. There are more very important factors in play for high frequency attenuation, such as the angle of incidence (2).

3.2 Real reverberation time correction compared to Fictive reverberation time correction

When the standard deviation of all data sets per frequency is compared between insertion loss that was obtained after the real reverberation time and insertion loss that was obtained using the fictive insertion loss, the for fictive reverberation results are more in line with the other measurements. This is shown in figure 9.

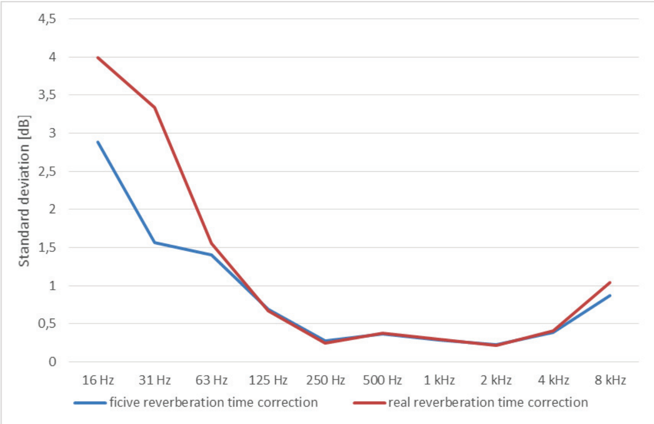

Figure 9 standard deviation for different reverberation time corrections

4. CONCLUSIONS

The currently tested attenuators with micro-perforates are market-ready for aggressive environments were the performance above 2 kHz is essential. For lower frequency performance some interesting trends were observed that require further investigation.

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