How to deal with reference absorbers – DAGA2021/622

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abstract

Sound absorption is the most important input factor to room acoustic calculations. The measurement of diffuse sound absorption is carried out in accordance to ISO 354 [ISO 354:2003], unfortunately the measured values are not as accurate as the planner would like. The ISO 354 is currently being revised, with a variety of approaches to improv the accuracy of the measurement. Sound absorption can not only be measured, but also calculated. In particular, the combination of calculation and measurement of normal incidence absorption provides an exact prediction of a perfectly diffuse absorption, just as it is used in a planning due to Sabine's equation. Therefore, the aim should be to modify the reverberation chamber since the theoretically known, perfectly diffuse, sound absorption is also measured.

reference absorber: ISO 354:2019

The draft ISO 354:2019 [ISO 354:2019] includes the use of a reference absorber. The absorption of this reference absorber, a 200 mm thick mineral wool (28 kg/m³, 11 kPa s/m²) is defined in the standard. This reference absorber must be tested in each reverberation chamber and by the deviation from the normatively defined values each measured sample has to be multiplied (correction factor γ).

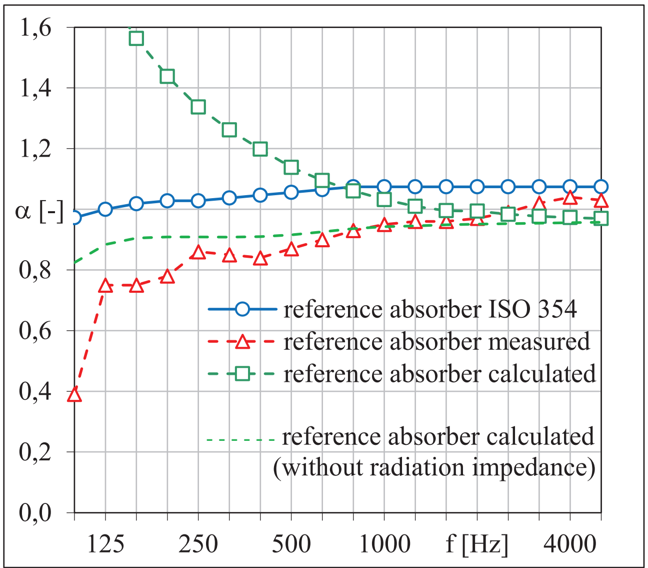

figure 1: reference absorber ISO 354:2019

	125	250	500	1 k	2 k	4 k
reference absorber ISO 354	1,00	1,03	1,06	1,07	1,07	1,07
reference absorber measured	0,75	0,86	0,87	0,95	0,97	1,04
reference absorber calculated	1,72	1,34	1,14	1,03	0,99	0,97
cor-fact γ ref-abs measured	1,33	1,20	1,21	1,13	1,11	1,03
cor-fact γ ref-abs calculated	0,58	0,77	0,93	1,04	1,08	1,10

table 1: reference absorber ISO 354:2019

Figure 1 shows the normatively defined reference absorber, as well as an average value of 12 measurements in the reverberation chamber of the Physikalisch-Technische Bundesanstalt (PTB) [PTB 2019] the value calculated according to Delany & Bezley [Heckel 1995] for ideal diffuse conditions. Table 1 shows the correction factor for the measured and calculated sound absorption as defined in draft ISO 354:2019

the true sound absorption

The calculation of porous absorbers (including foils, tissues and perforated panels) is described by F.P. Mechel in his trilogy »Schallabsorber« Volume I to III [Mechel I, II, III]. Volume III contains a generally valid calculation scheme for multi-layer absorbers. This allows the sound absorption to be calculated for vertical as well as ideally diffuse sound incidence.

In the case of locally reacting absorbers, e.g. mineral wool, it is particularly important to take into account the edge effect, this can be done in form of the radiation impedance for rectangular absorbers [Mechel I]. The accuracy between calculation and measurement can be described as excellent [Häusler 2013].

Sabine's equation

Room acoustics are planned worldwide by using Sabine's equation:

$$T = 0{,}16\ V/A \qquad [s]$$

Unfortunately, Sabines equation is only valid for a diffuse sound field, this assumes:

- evenly distributed absorption
- not too high mean absorption: < 25%
- none too extreme dimensions: 1 to 5
- volume not too large: V < 2000 m³
- volume not too small: $f_{Sch} = 2000 \sqrt{V/T}$

In case of good planning, i.e. a reasonable distribution of the absorbent surfaces, the preconditions in conventional rooms are often given. The onset of diffuse sound behaviour can be described by the Schroeder frequency [Nelson 1992], in a typical classroom about 100 Hz (200 m³, T = 0,5 s => f_{Sch} = 100 Hz). However, in a typical reverberation chamber it is about 400 Hz (200 m³, T = 8,0 s => f_{Sch} = 400 Hz).

reverberation chamber

The measured values in the reverberation chamber, especially at low frequencies less than $f_{Sch}/2$, do not correspond to the expectation of diffuse sound absorption, as we can see in figure 1. However, as long as the absorption is low, this problem does not occur, as we can see in figure 2 and 3. The corrected values are far worse than without correction. Therefore, the correction factor introduced by the draft resolution of ISO 354 doesn't make any sense, even if there might be same improvements at high frequencies.

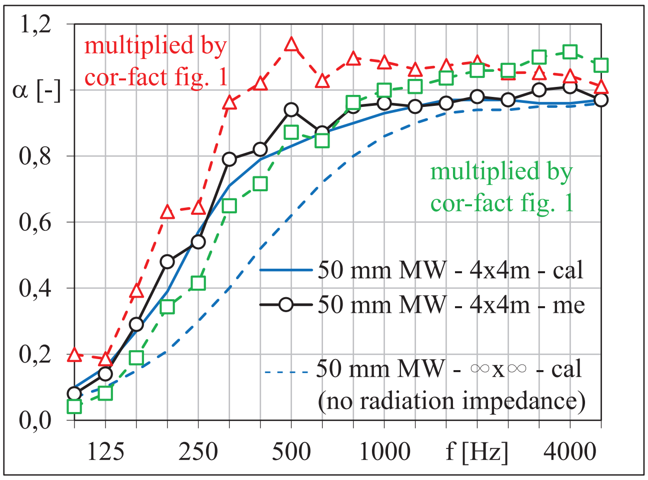

figure 2: mineral wool, 50 mm (50 MW)

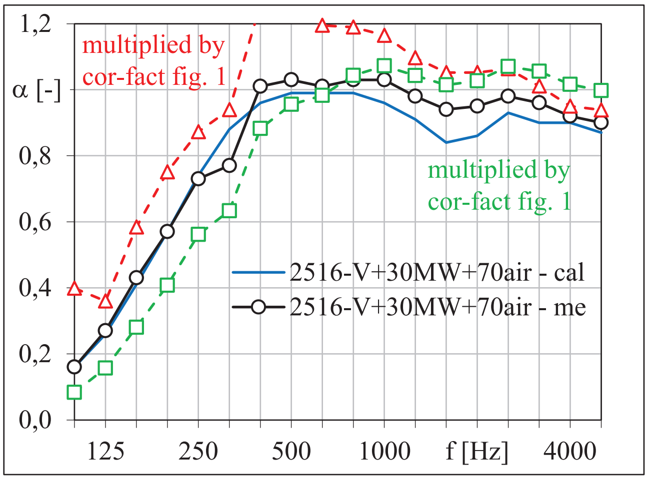

figure 3: perforated metal panel 2516 V, 30 MW, 100 mm

Instead of correcting questionable measured values afterwards, the reverberation chamber should be optimized in such a way that it is measured correctly. Therefore, the modal overlap has to be increased, what means that the reverberation time al low frequencies has to be reduced.

It is recommended to position appropriate absorbers in the corners of the reverberation room. That this is well possible has already been sufficiently documented [Fuchs 2007]. So the sound absorption can even be measured well up to 50 Hz, an example of this shows figure 4.

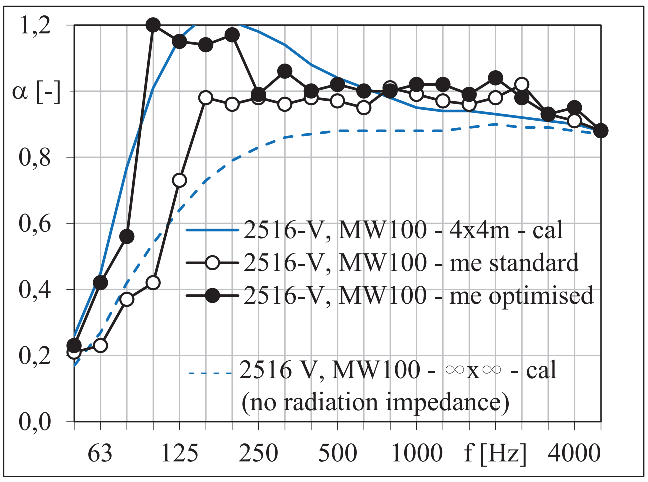

figure 4: perforated metal panel 2516 V, 100 MW

reference absorber: new attemp

Since the absorption of porous absorbers is well known, they can be used to optimize the reverberation chamber. For this you should take absorbers with different frequency curves (e.g. figure 5) and optimize the reverberation space until all reference absorbers are measured sufficiently accurately. Essentially, three improvements are needed:

- frame around the absorber must be optimized
- diffusity off the surfaces must be improved
- increased damping at low frequencies (modal overlap)

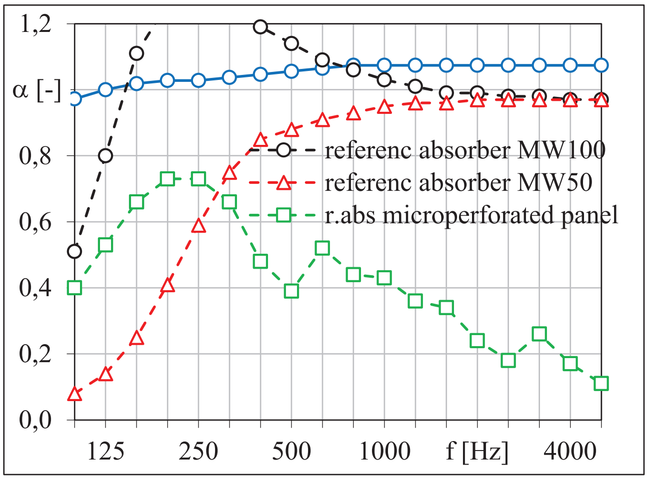

figure 5: 100 MW, 500 MW, microperforated metal panel

conclusion

A reference absorber for the correction of measured values increases the effort without getting closer to diffuse absorption. Since the ideal diffuse absorption of porous absorbers is known from the calculation, such absorbers can be used to optimise the reverberation chamber.

The aim should be to modify the reverberation chamber in such a way that the theoretically known, perfectly diffuse, sound absorption of different reference absorbers is measured correctly, than further corrections are not necessary.

references

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