Acoustical transparency of perforated panels with fabric linings

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Introduction

In contemporary design of open-plan offices, convention centres, banks, shopping centres and public spaces, walls and ceilings with visually smooth surfaces are often desired (Figure 1). At the same time, acoustic conditions have to be created which support an intense communication that the services offered in these rooms require [1]; the reverberation time shall be tuned accordingly. It is difficult to fulfil those two requirements below 500 Hz because both, furnishing and persons absorb less in this frequency range – and they are often the only sound absorbers in the room. That is why low frequency absorbers shall be installed behind a visually smooth cover. This cover must allow sufficient sound transmission in the frequency range of interest. A measuring method is presented for the estimation of sound transmission at normal incidence. Only small samples (0,25 x 0,25 m) of the cover are necessary. Measurement results of typical absorber covers are discussed.

Figure 1: Sound absorber behind visually smooth surfaces [2].

Measuring method

The complex reflection factor r is measured following [3] in a setup according to Figure 2. The reflection coefficient $\rho = |r|^2$ is calculated. The transmission coefficient τ is determined from the pressure level difference $\Delta L_p = L_{p,i} - L_{p,M3}$ between positions M2 and M3 according to

$$\tau = 10^{-\Delta L_p/10}$$

The measured pressure level $L_{p,M2}$ at M2 has to be corrected using the previously found reflection factor r in the equation

$$L_{p,i} = 10 \lg \frac{10^{L_{p,M2}/10}}{|e^{-jk_0x_2} + re^{jk_0x_2}|^2}$$

to the level $L_{p,i}$ of the incident wave, where $k_0 = 2\pi/\lambda$ is the wave number and x_2 the distance between position M2 and the sample surface. Figure 3 shows measurement results of the empty duct and of a d = 0,3 mm thick fabric with a mass per unit area of 0,13 kg/m^2 and a specific flow resistivity of Ξ = 400 kPa*s/m^2. Considering flow resistivity only, the simplified estimation of the transmission coefficient of the fabric is (with the ρ = 1,2 kg/m^3 and c = 343 m/s)

$$\tau = \frac{1}{\left(1 + \frac{\Xi d}{2\rho c}\right)^2} \approx 0{,}76$$

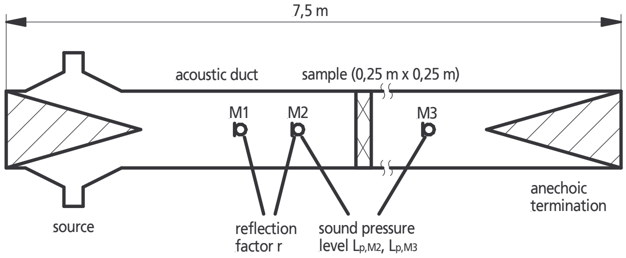

Figure 2: Acoustic duct with anechoic source and termination, and microphone positions M1, M2, M3 for reflection factor and sound pressure level measurement.

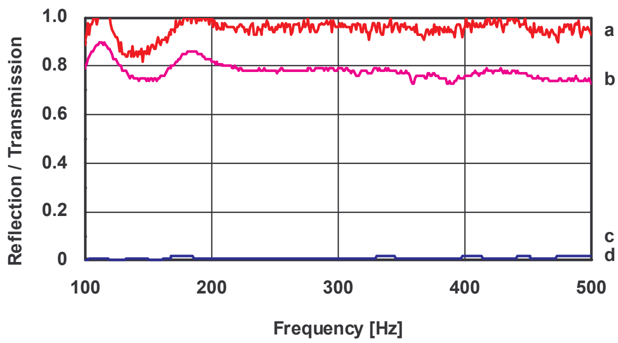

Figure 3: Transmission coefficient τ of the empty duct (—, a) and of a fabric sample (—, b); Reflection coefficient ρ of the empty duct (—, d, straight line at 0) and of a fabric sample (—, c).

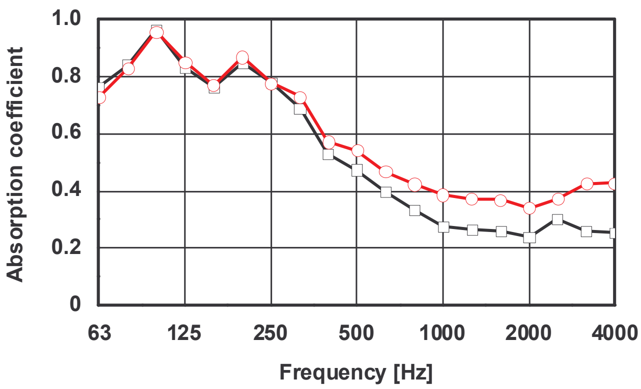

Figure 4: Absorption coefficient α_s of Compound Panel Absorbers without (□) and with (○) a fabric cover.

This is in good agreement with the measurement result. In order to check the influence of such a cover, the more practical measurement of the sound absorption coefficient at random incidence according to [4] was carried out in a reverberation chamber. Two sequential measurements, the first without and the second with a fabric cover show, that there is no detrimental influence of the fabric on the performance of Compound Panel Absorbers according to [5] (Figure 4).

Measurement of covers

A first option for a visually smooth cover of absorbers is perforated gypsum plaster board, which has a layer of fleece on the side facing the room. The fleece is then painted. A series of 4 samples has been tested. Sample 1 was unpainted, sample 2 and sample 3 were speckled with a thin layer of a "sound-transparent renovation paint" once and twice, respectively. The paint on samples 1 to 3 was not yet top-dressing. More paint had to be applied to make sample 4 meet the visual requirements. The measured reflection and transmission coefficients in Figures 5 und 6 show, that samples 1 and 2 are suitable to cover absorbers from a merely acoustical point of view. Samples 3 and 4 should not be employed for this purpose since they reflect the larger part of the incident sound energy.

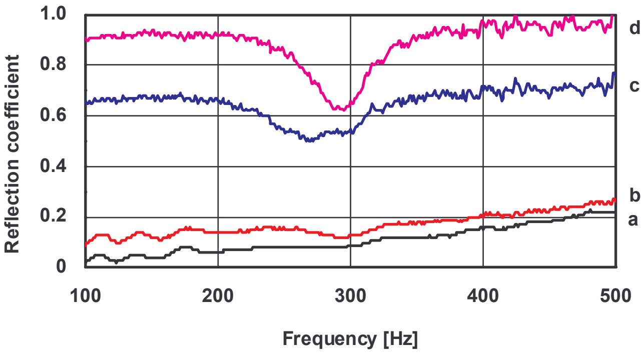

Figure 5: Reflection coefficient ρ of gypsum plaster board samples with fleece cover and no paint (—, a), 1 thin layer of paint (—, b), 2 thin layers of paint (—, c), and top-dressing layer of paint (—, d).

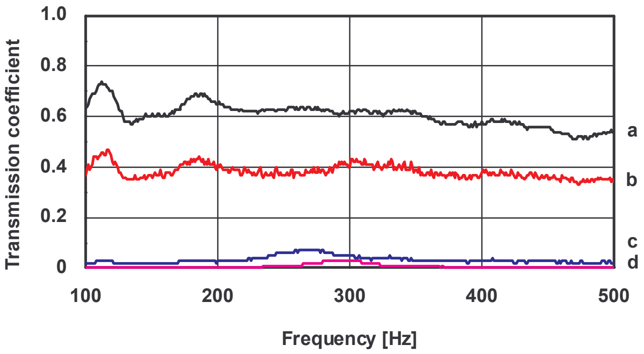

Figure 6: Transmission coefficient τ of gypsum plaster board samples with fleece cover and no paint (—, a), 1 thin layer of paint (—, b), 2 thin layers of paint (—, c), and top-dressing layer of paint (—, d).

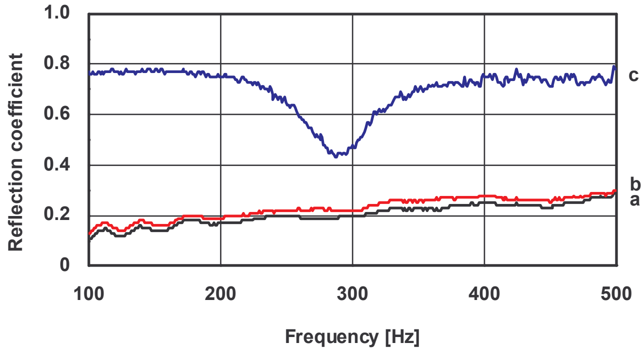

Figure 7: Reflection coefficient ρ of 26 mm thick porous recycling glass with glass fiber fleece layers on both sides, without (—, a) and with (—, b) an additional cover of porous plaster, and of a panel made of compressed mineral fibre for an acoustic suspended ceiling system (—, c).

A second option for absorber covers are panels made of sintered porous glass as described in [6] with a layer of porous plaster on top. The measurement results in Figure 7 show a negligible influence of the plaster layer and that, inspite of its thickness of 26 mm, this material is significant better qualified for acoustically transparent covers than option one described above. A third option, paint covered panels made of compressed mineral fibre for an acoustic suspended ceiling system, achieved results (Figure 7) similar to samples 3 and 4 of the perforated gypsum board (Figure 5).

Summary

The measuring method described allows an estimation of the reflection and transmission coefficient of small samples at normal sound incidence. Samples of perforated gypsum plaster board, covered with fleece lost their acoustical transparency when coated with a top-dressing layer of "sound-transparent renovation paint". They should not be used to cover absorbers, nor should paint covered panels made of compressed mineral fibre. A more suitable material for this purpose is sintered porous glass with a top layer of porous plaster.

References

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