Comparison measurements at the Physikalisch-Technische Bundesanstalt in the year 2016

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Summary

In 2016, it was PTB's turn to host the comparison measurements of the approved test centers for building acoustics in Germany. For these test centers, regular participation in comparison measurements is mandatory; however, other test centers are free to attend. Over the years, these comparison measurements have proven to be an important building block of quality assurance. The measurements encompass three partial measurements as well as the testing of loudspeakers and tapping machines. The measurement results of the test centers are compared with a reference value from PTB.

That year, the partial tasks were to measure the airborne sound insulation of a thick lime sand brick wall and the impact noise level of a stair element. As an additional task, the loss factor of the lime sand brick wall was determined. During the loss factor determination, a significant dependence of the results on the type of excitation (shaker or hammer) became visible. By applying very high airborne sound excitation, it could be shown that non-linearities cause the discrepancies. The results of the individual measurements will be presented and consequences for the hammer excitation of the walls will be discussed.

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1. Introduction

The sound insulation of buildings is a major quality feature. To ensure the planned acoustic quality, the sound insulation of buildings is predicted from measured sound insulation of building elements. These measurements are mostly undertaken by testing laboratories which hold a formal approval by the highest building authorities of the German countries. These testing laboratories are required to take part in comparison measurements which take place at Physikalisch-Technischen Bundesanstalt (PTB) once in 3 years. As a means of quality assurance, other test institutes also have the possibility to take part in these measurements. This contribution gives a report on the comparison measurements of the year 2016.

For each comparison measurement, test specimens are newly selected. This time, the impact noise of a metal stair with PVC flooring had to be measured. The receiving room was an adjoining office. Also, the airborne sound insulation of a lime brick wall with a surface mass of m = 440 kg/m² and a thickness of d = 24 cm was to be measured. The wall is mounted in PTBs wall test facility and plastered from both sides. Additionally, the loss factor of the wall had to be measured.

To have a reference value, 5 independent measurements are performed by PTB for each task. The critical difference is then calculated from the empirical standard deviation s of the 5 reference results for a confidence level of 95 % by

$$x_{crit} = 2.776\, s \sqrt{\frac{1}{5} + 1} \tag{1}$$

This critical difference is applied to all measurands i.e. to measured impact noise levels, airborne sound reduction index and loss factors. All these quantities are handled as levels in dB in one-third octave bands between 50 Hz and 5 kHz.

2. Results for airborne sound insulation and impact noise levels

Since standards changed during the comparison measurements, the application of [1], [2] and [3] was stipulated. All 12 participating laboratories used their own equipment for the measurements. For the sound level meters used, participating laboratories presented valid certificates of compliance with the requirements. Furthermore, loudspeakers and tapping machines were tested by PTB to ensure that these devices are in conformity with the requirements of the standards. Altogether 29 loudspeakers and 17 tapping machines were tested. Three loudspeakers and one tapping machine did not comply with the requirements.

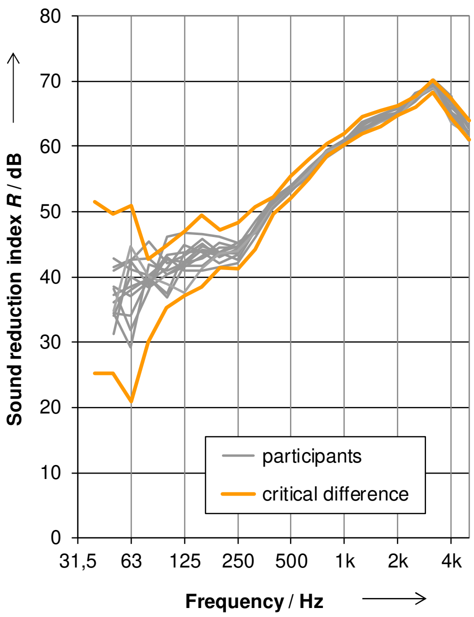

Figure 1 Airborne sound reduction index measured by the participating laboratories

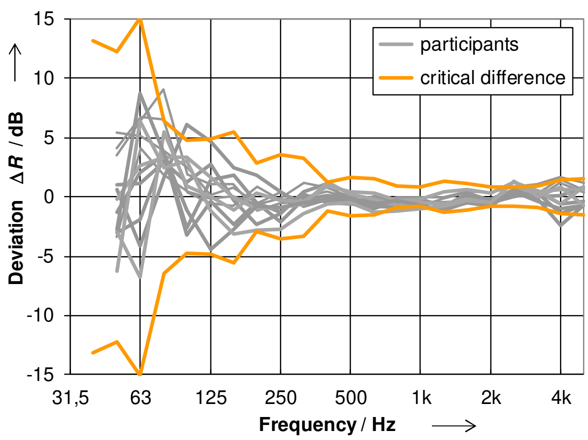

Figure 2 Airborne sound reduction index, deviation to the reference value

The participants' results are very well within the expected range (Figure 1 - Figure 4). The critical difference is exceeded only by single band levels.

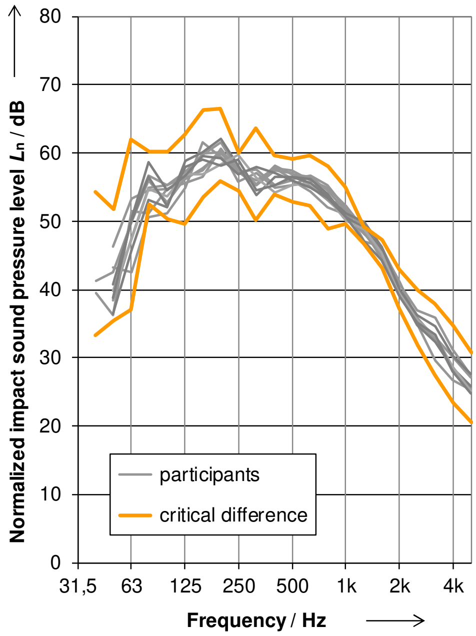

Figure 3 Impact noise levels measured by the participating laboratories

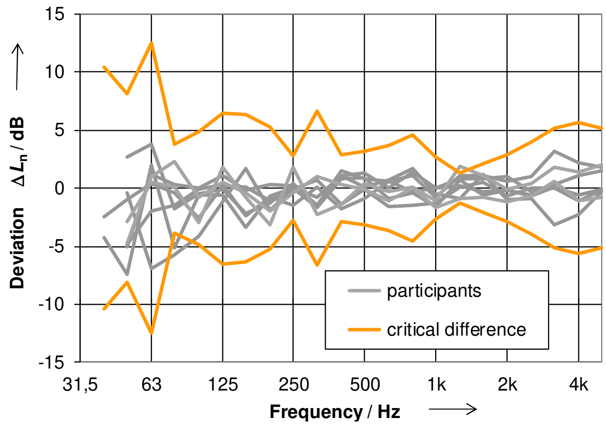

Figure 4 Impact noise level, deviation to the reference value

3. Results for the loss factor

The loss factor η was measured by PTB and the participating laboratories according to [5]. It is expressed here in dB as

$$L_\eta = 10 \lg \frac{\eta}{10^{-12}} \mathrm{dB} \tag{2}$$

Measured values exhibit a significant scatter which is larger than expected from the scatter of the reference measurements (Figure 5). A further analysis revealed that 5 laboratories used a shaker and 4 a hammer to excite the wall. Three laboratories did not participate in this part of the comparison measurement. A dependence of the measured loss factor on the excitation used is clearly observed (Figure 6). Hammer excitation yields larger loss factors than shaker excitation. This has already been observed in the past, e.g. [6] and [7] where nonlinear effects seemed to be the most likely explanation for this behaviour.

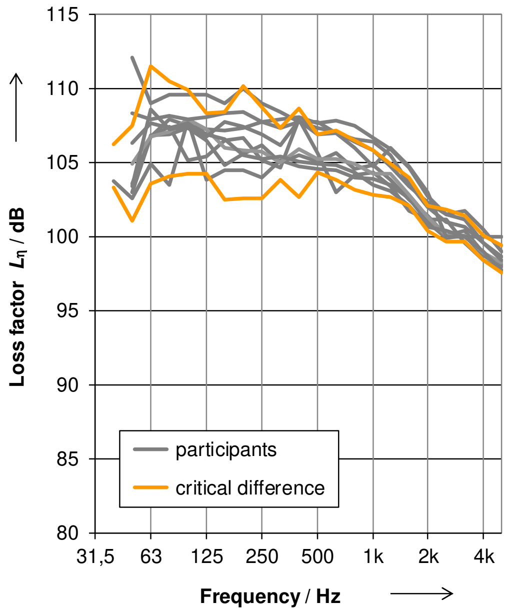

Figure 5 Measured loss factor in dB

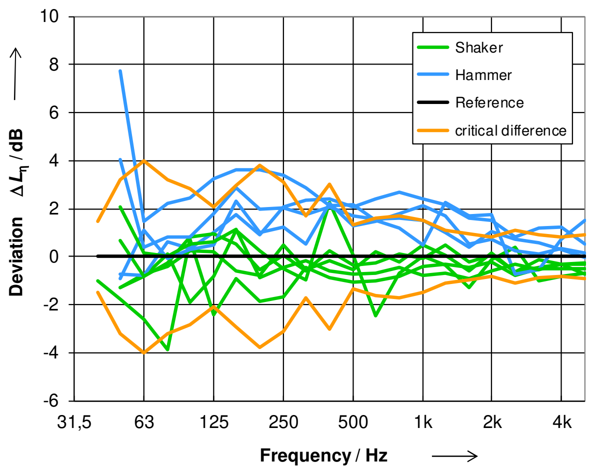

Figure 6 Loss factor, deviation to the reference value

4. Nonlinearities in sound insulation

If damping is nonlinear, airborne sound insulation should also be nonlinear. Therefore, the effect of very high exciting airborne noise levels was investigated. Using standard loudspeakers with sound pressure levels up to 125 dB in the sending room, no nonlinearity could be observed. This was checked by the sound pressure level difference between sending and receiving room since the equivalent absorption area is considered to be constant for different excitation levels. To produce even larger sound pressure levels, alarm pistols with different ammunition were used. Thereby sound pressure levels from 125 to 134 dB could be reached. The sound pressure level difference between sending room and receiving room then showed a significant increase with increasing sending room level (Figure 7, Figure 8). The effect is visible for all frequencies starting at 250 Hz (Figure 9). It is furthermore interesting to notice that the rate of change is nearly constant for different frequencies (Figure 10).

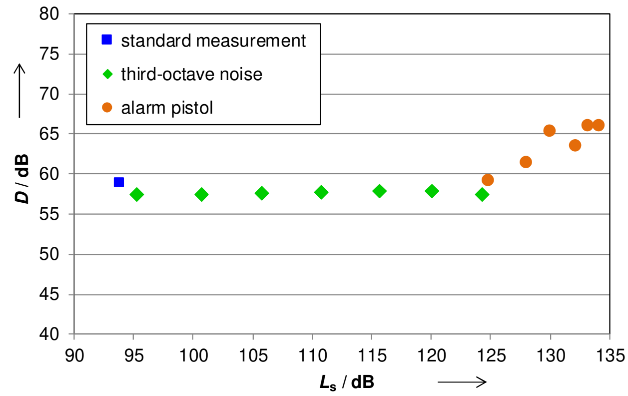

Figure 7 Sound pressure level difference between sending and receiving room at 1 kHz for different sending room levels

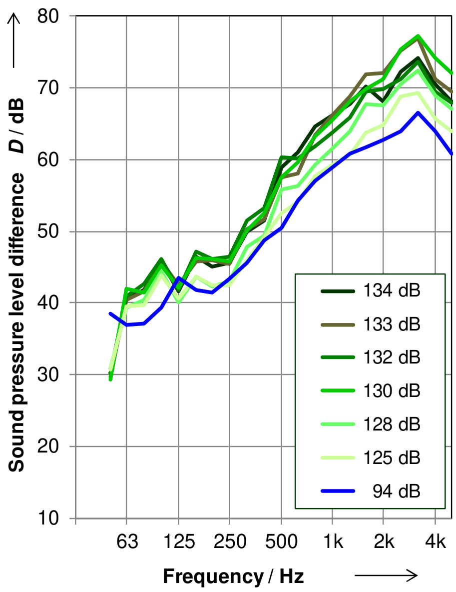

Figure 8 Sound pressure level difference between sending and receiving room for different sending room levels (Given numbers correspond to the sending room level at 1 kHz.)

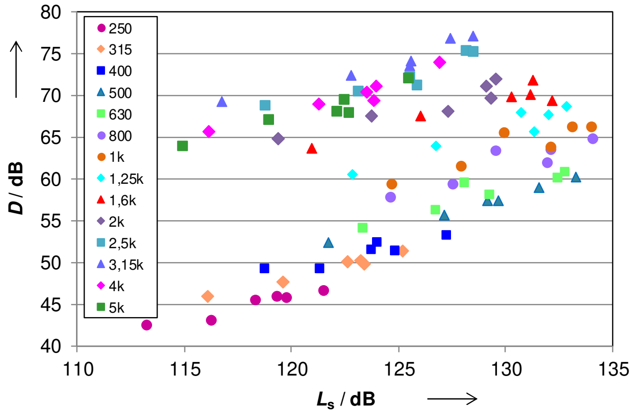

Figure 9 Sound pressure level difference between sending and receiving room as a function of sending room levels

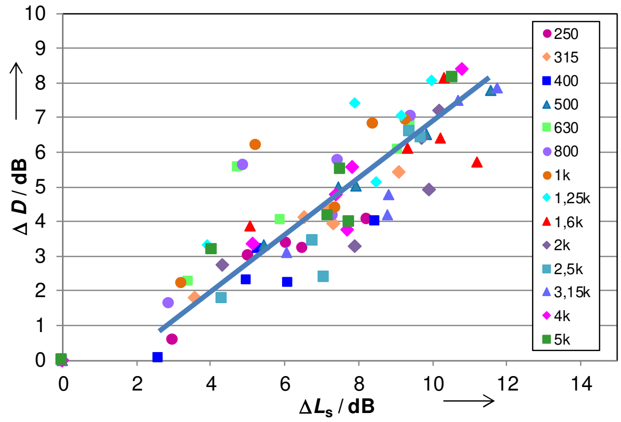

Figure 10 Change of sound pressure level difference between sending and receiving room as a function of the change of sending room levels

5. Conclusion

PTBs comparison measurements in the year 2016 confirmed the high quality of building acoustic laboratories in Germany. Impact noise levels and airborne sound reduction indices measured by the participants are consistent with the reference values determined by PTB.

The measurement of the loss factor revealed that hammer and shaker excitation lead to inconsistent results. By applying shooting noise with extremely high levels, the suspicion could be substantiated that nonlinearities in the damping mechanism are responsible for the observed deviations. With respect to the development of measurement procedures with a horizontally acting tapping machine, these findings raise some questions. In particular, it has to be investigated which mechanisms are responsible for the nonlinearities, which types of specimen are likely to show a nonlinear behaviour and what the linear range is.

Acknowledgement

References

[1] ISO 16283-1: 2014 Acoustics - Field measurement of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation

[2] ISO 140-7: 1998 Acoustics - Measurement of sound insulation in buildings and of building elements - Part 7: Field measurements of impact sound insulation of floors

[3] ISO 140-14: 2004 Acoustics - Measurement of sound insulation in buildings and of building elements - Part 14: Guidelines for special situations in the field

[4] ISO 10140-5: 2010 Acoustics - Laboratory measurement of sound insulation of building elements - Part 5: Requirements for test facilities and equipment

[5] ISO 10848-1: 2006 Acoustics -- Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms -- Part 1: Frame document

[6] Schmelzer, Muncke: Verlustfaktormessungen mit unterschiedlichen Anregungsarten, DAGA 2012 in Darmstadt

[7] Bietz, Wittstock: Comparison of different methods for the determination of the structure-borne noise reverberation time, CFA/DAGA 2004 in Straßburg