Sound Insulation Test Facilities Yielding Deviating Measurement Results Although Conforming to ISO 140

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Introduction

In Germany, each laboratory wishing to make official measurements in building acoustics must be licensed by the Deutsches Institut für Bautechnik (DIBt). Before such a licence can be obtained, the laboratory has to undergo a technical inspection by the Physikalisch-Technische Bundesanstalt (PTB). Regarding the sound reduction index of walls, the laboratory has to take part in a round robin test for solid heavy walls, which started in 1998 and is continued since [1]. The test object is in this case a calcium silicate brick wall with thin layers of plaster at each side, total thickness 25 cm, mass per unit area 440 kg/m². The stones are heavy (1700 kg/m³) and almost without any holes in order to keep off thickness resonances. A 'new' laboratory is expected to meet the requirements of ISO 140-1 [2] concerning size, shape, damping of the test object, flanking transmission and reverberation times and, in addition, to yield sound insulation indices for the round robin test specimen close to previous results. In this paper a case is reported where ISO 140-1 was perfectly met but where the round robin test yielded large deviations. Research was financed in this case by DIBt [3].

The tested laboratory

Figure 1 shows the principal construction of the examined transmission suite for wall measurements. The specimen is installed in a concrete frame which is structurally disconnected from the two adjacent rooms. The complete setup is elastically bedded on the ground. The object area is about 10 m², the room volumes are about 55 and 60 m³. Remarkable is the shape of the rooms: They are tapered towards the specimen. Figure 2 shows the sound reduction index (SRI) of the 'new' test facility compared with former results for the round robin test wall. Above 300 Hz, the 'new' values lie within the range of results of other laboratories, but mainly close to the lower limit. Around 250 Hz, the results fall short of all the previous values. Below 100 Hz the 'new' values exceed all former results by up to 10 dB. As this perhaps meant an unfair privilege, the reasons had to be clarified. At first it could be shown, that the same kind of deviations occurred again when the calcium silicate wall was removed and replaced by the same type of wall.

Apparently high sound reduction values

The following reasons can cause unexpectedly high sound reduction index values, either apparently or actually:

- overestimation of the source room SP-levels
- underestimation of the receiving room SP-levels
- mode mismatch between source room and wall
- mode mismatch between wall and receiving room
- energy losses of the wall into the laboratory walls
- change of the boundary conditions for the test wall.

The different reasons can be related to each other. The change of boundary conditions can cause a change of the modal match of the parts of the test setup.

Overestimation of excitation

Calculations were carried out to simulate the sound fields in the two rooms of the transmission suite. It showed that, due to the special shape of the rooms in the present case, there are many modes where the energy of the sound field concentrates in the room part opposite the test object. That means, the high average sound pressure level in the source room indicates sound energy which never reaches the test object. Vice versa, in the receiving room, modes with a nodal plane in front of the test wall can hardly be excited by the wall. Examples of such modes are presented in figure 3.

Modal mismatch

In the system under investigation, strong sound energy would be transmitted from the source to the receiving room if there were modes of the receiving and sending rooms and the separating wall with similar natural frequencies and vibrational patterns well matched on the boundary surfaces. In the case of the present example, this did not occur between about 60 and 100 Hz, thus giving rise to a high sound reduction index in this range. In addition, this state is very unstable as the minimum required reverberation time in the rooms of 1 s corresponds to a half-power bandwith of the room modes of 2,2 Hz which means that small shifts in the room geometry, position of the absorbers, or boundary conditions of the test object can change the situation drastically (cf. figures 4 and 5).

Energy loss into the laboratory

To check the influence of energy loss from the test wall into the laboratory structure on the sound reduction, the sound reduction indices of previous round robin participants were compared with the 'new' results after correction for the total damping factor of the test walls. As can be seen in figure 9, this correction does not bring together the curves at low frequencies, thus indicating that high damping of the test wall is not the reason for the high SRI values.

Underestimation of the sound field

ISO 140 requires minimum distances of the microphone orbits from the loudspeakers, test wall and room boundaries and a minimal inclination of the microphone orbit of 10°. But these requirements are not sufficient. With modes where midplanes are nodal planes it is possible to stay within silent areas of the sound field of the rooms, thus underestimating the energy in the sound field and pretending high SRI values.

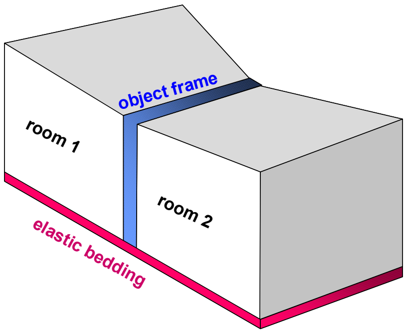

Figure 1: Shape of the investigated transmission suite

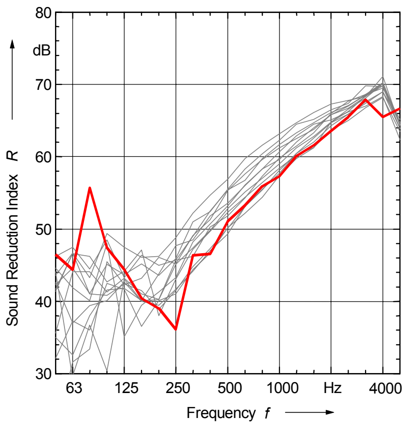

Figure 2: Sound reduction index of the 'new' lab compared with previous results from other round robin test participants

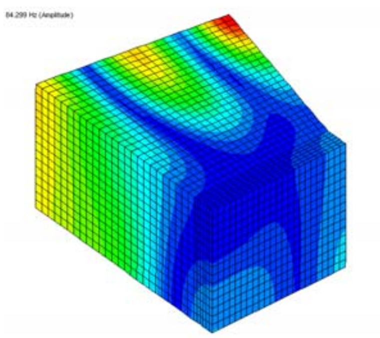

Figure 3: Room mode with low energy towards the test wall (dark blue area at the right side)

Conclusions

Oblique angled rooms which are tapered toward the test objects should be avoided. When inevitable, diffusors should be used. Microphone cycles and loudspeaker paths should be extended as fas as possible (radius > 1,5 m, length > 2 m) and be inclined near 45°. Midplanes should be avoided! An increased modal density of the test objects is desirable and could be achieved by test objects which exceed by far the test opening of the transmission suite. An increased damping of the test setup is also desirable to increase the modal overlap.

References

[1] Meier, A., Schmitz, A., Raabe, G.: "Inter-Laboratory Test of Sound Insulation on Heavy Walls, Part I - Preliminary Test, Part II - Results of Main Test", Building Acoustics, Vol. 6, Numbers 3/4, 1999

[2] ISO 140-1: Acoustics - Measurement of sound insulation in buildings and of building elements - Part 1: Requirements for test facilities with suppressed flanking transmission, 1997

[3] Weise, W., "Ursachen signifikanter Abweichungen von Messergebnissen aus unterschiedlichen, nach der europäischen Norm DIN EN ISO 140 normgerechten Prüfständen ," Report for DIBt, Az.: P 32-5-5.71-1033/02

Figure 4: Gypsum board in the corner to change radiation conditions of the test wall

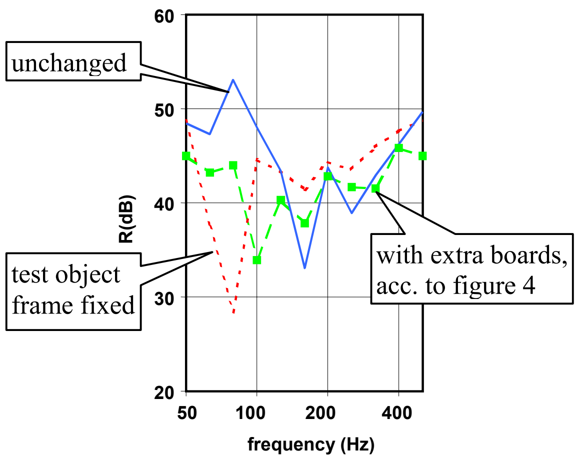

Figure 5: Variation of SRI by modifications of the test wall boundary conditions