Effect of airborne sound on installation noise

Part 2: Practical application

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Introduction

The noise excitation of buildings by service equipment takes place by both structure-borne and airborne sound. Mostly sound transmission is determined by the structure-borne portion. For some sources, however, the contribution of airborne sound can't be neglected. A typical example is the EMPA-hammer, defined in the Swiss Standard SIA 181 [1] as a standardized source for the simulation of user noise. If airborne sound contributes substantially, conventional measures for noise reduction based on elastic isolation between source and building won't work properly. In order to develop efficient measures for that kind of excitation, structure-borne and airborne sound must be separated and investigated in context with each other.

Emergence and transmission of installation noise

While exciting a sanitary object the resulting installation sound level measured in adjoining rooms is mainly caused by structure borne sound transmission through the mounting points of the sanitary object with the building structure (see Figure 1).

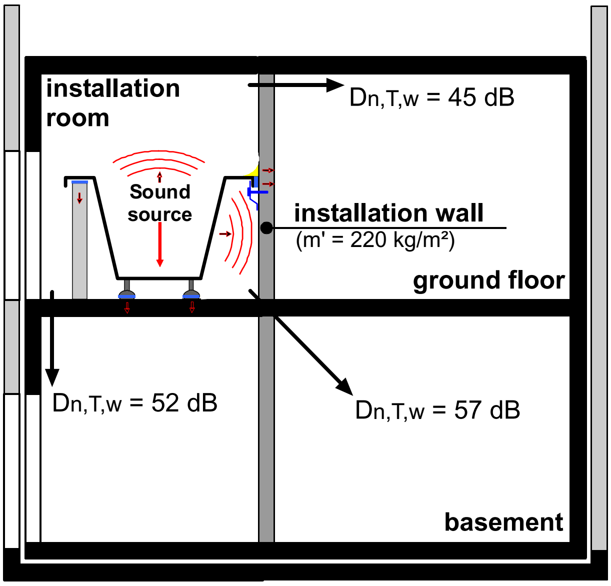

Figure 1: Airborne and structure-borne sound transmission of sanitary objects. Sketch of the installation test facility at the Fraunhofer-Institute for Building Physics (IBP). The values of sound insulation mentioned in the drawing refer to the IBP installation test facility in connection with installation walls with a mass per unit area of 220 kg/m² installed in the basement and the ground floor (standard wall according to DIN 4109 [2].)

Depending on the structure-borne sound power of the exciting sound source and the mobility of the sanitary object the resulting noise level in the installation room can reach up to 100 dB(A). The resulting transmission of airborne sound into adjacent rooms of course depends on the sound reduction index of the building structure.

Comparison of noise sources

Installation noise can be subdivided into the two main categories of user noise (e.g. dropping of toilet seat) and operation noise (e.g. WC-flushing). Particular high sound levels are caused by user noise, concerning airborne as well as structure-borne sound. The main reason for this problem is the very large structure-borne sound power of many kinds of user excitation.

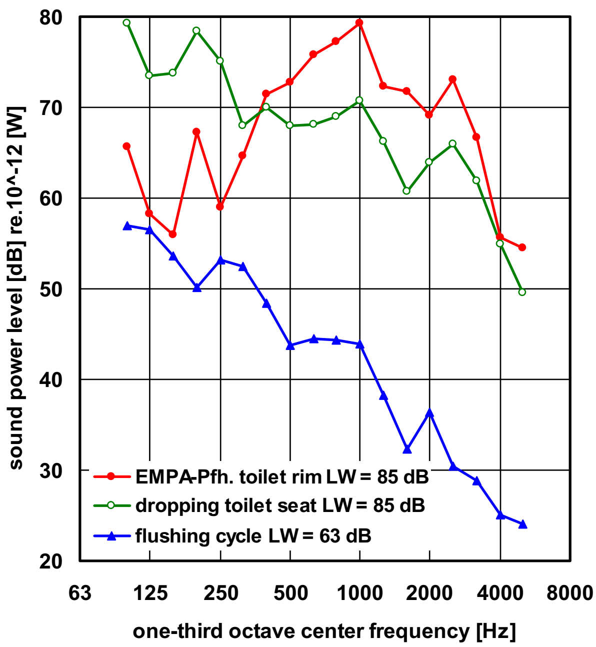

Figure 2: Structure-borne sound power levels of EMPA-hammer and dropping of toilet seat in comparison with a WC flushing cycle (corresponding experimental setup see figure 3).

Figure 2 shows the characteristic structure-borne sound power levels of a WC-system measured with the reception plate method according to DIN EN 15657-1:2007-05 [3]. The WC-system was excited by two types of

<u>user noise</u> EMPA-Pendelfallhammer and dropping of toilet-seat,

in comparison with the

<u>operation noise</u> WC flushing cycle.

Figure 3: Test set-up, WC-system on the reception plate (corresponding measuring results see figure 2).

As can be seen from figure 2 user noise typically transmits over 20 dB more energy into the receiving structure than a typical operation noise.

Separation of structure-borne and airborne sound

The sound emission of an installation noise divides into the structure-borne sound part which is transmitted through the mounting points of the sanitary object into the building structure and the airborne sound part radiated from the sanitary object into the installation room. For service equipment with effective elastic isolation the airborne sound part contributes substantially to the measured installation sound level in adjoining rooms.

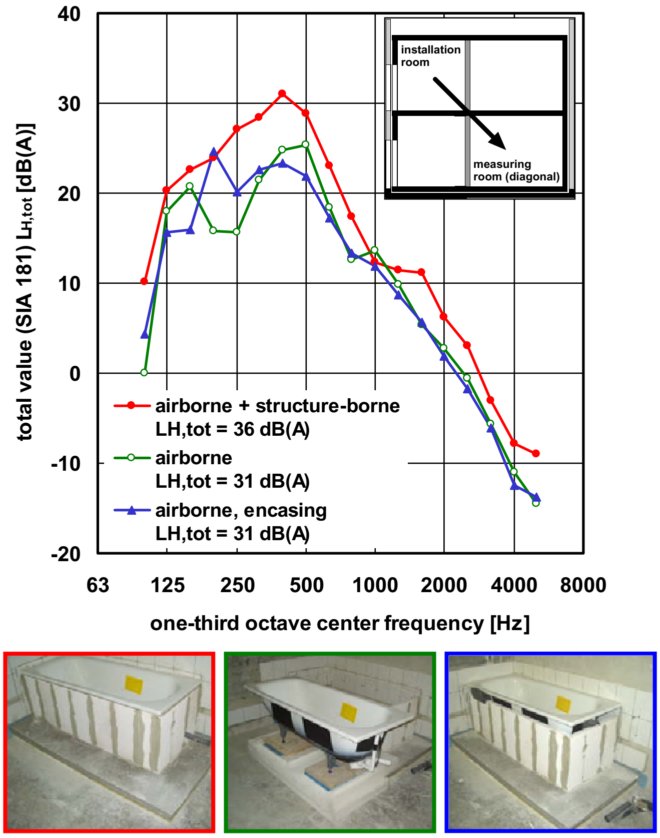

Figure 4: Measured installation noise in an adjoining room (diagonal to installation room) by exciting a bath tub with the EMPA-hammer and different test set-ups. The red curve results from a measurement under practical conditions consisting of a bath tub mounted on a floating floor with enclosure (5 cm aerated concrete). The green curve shows the same bath tub with a very effective structure-borne sound insulation from the building structure. The blue curve is measured also with an optimum of structure-borne sound insulation but inside the enclosure. The comparison of the three curves reveals that at some frequencies the airborne sound part is equal to the structure-borne sound portion or even dominates the resulting installation noise.

The results in Figure 4 demonstrate the contribution of the airborne sound radiation of the sanitary object (excited by the EMPA-hammer) on the installation sound level measured in adjoining rooms. Also notable is the increased noise level at 200 Hz referring to the measurements on the bath tub with the structure-borne sound insulation placed inside the enclosure (blue curve) which is effected by the cavity resonance in the encasing and the near field sound radiation of the bath tub [4].

Summing up, the reachable installation sound level mostly depends on the structure-borne sound insulation but in some cases (especially for user noise) also on the height of the airborne sound radiation of the sanitary object.

Reduction of installation noise

The structure-borne sound insulation of service equipment is mostly realized with elastic mounting elements between the sanitary object and the building structure (e.g. pipe clamp with rubber inlay). If the airborne sound radiation of a sanitary object (especially while excited by user noise) noticeably contributes to the installation sound level in adjoining rooms additional ways for a sound level reduction has to be investigated. There are several methods to reduce the airborne sound radiation of a sanitary object. In various practical measurements in the installation test facility in the Fraunhofer-Institute for Building Physics in Stuttgart the efficiency of the following measures have been investigated:

- **increasing the loss-factor of bath and shower tubs (damping of structure-borne sound),**
- **porous absorption in the installation room and in the enclosure of the tub (damping of airborne sound).**

Vibration damping of bath and shower tubs

Frequently bath and shower tubs are equipped with 4-5 mm bitumen mats by the manufacturer.

Figure 5: Bath tub with bitumen mats

The results in Figure 6 show, that optimization of the damping layers significantly reduces the installation noise.

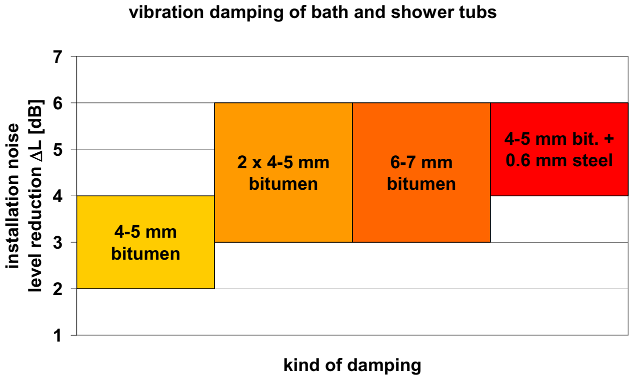

Figure 6: Level reduction of user noise (EMPA-hammer) by different variations of vibration damping.

Often there has to be found a compromise between an effective structure-borne sound insulation with elastic materials and the mechanical stability of the installation. With vibration damping on bath and shower tubs there is an additional way to improve the sound level reduction without reducing stability. In particular the damping of steel plates with a viscous-elastic-layer (bitumen) covered by a thin steel plate allow high loss factors and consequently a considerable reduction of installation noise (see Figure 7). This especially applies to tubs made of sheet steel.

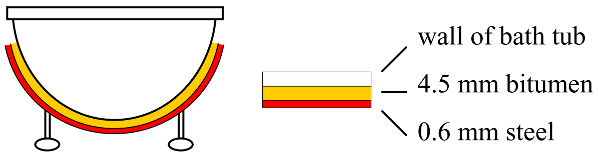

Figure 7: Bath tub with 4.5 mm bitumen mats coated with a 0.6 mm steel layer. The wall of the bath tub has a thickness of about 2 mm.

Reduction of airborne sound transmission of sanitary objects

As seen in “Effect of airborne sound on installation noise – Part 1: Basic investigations” [5] encasing of the gap between sound source and excited building element causes an increased sound pressure level inside of the gap. Results of measurements on shower tubs showed a similar effect. The measured installation sound level increased by more than 3 dB solely because of encasing of the gap!

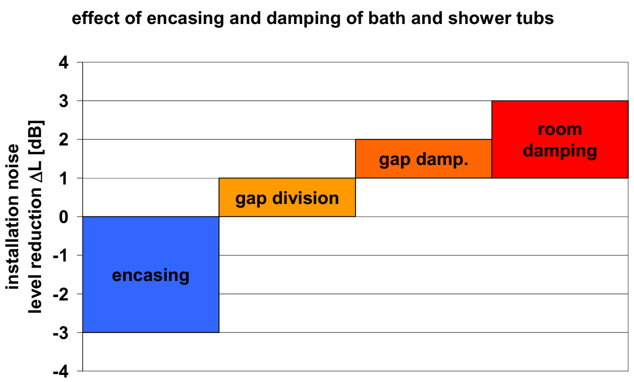

Figure 8: Level reduction of user noise (EMPA-hammer) by different kinds of damping and encasing (see Figure 9).

Figure 9: Test set-ups for the results in Figure 8: gap division (yellow, left), porous absorption for damping of the airborne sound field in the gap (orange, middle) and absorbing shield above the sanitary object (red, right).

The investigations on reducing the airborne sound transmission of sanitary objects by dividing the gap between the tub and the building structure and by damping of the gap provided moderate improvements (up to 2 dB). The absorbing shield above the sanitary object was more effective but infeasible in praxis.

Summary

User noise from sanitary installations can produce high sound levels in adjoining rooms as well as in the installation room itself. Often airborne sound radiation of the sanitary object significantly contributes to installation noise. The airborne contribution depends on the structure borne sound insulation of the sanitary objects. For installations with effective structure-borne sound insulation the reduction of the airborne sound radiation with e.g. bitumen mats can be decisive to meet the noise protection requirements given by building law.

References

[1] SIA 181:2006, Schallschutz im Hochbau. Schweiz.

[2] DIN 4109:1989, Schallschutz im Hochbau; Anforderungen und Nachweise.

[3] DIN EN 15657:2007-05, Acoustic properties of building elements and of buildings - Laboratory measurement of airborne and structure borne sound from building equipment - Part 1: Simplified cases where the equipment mobilities are much higher than the receiver mobilities, taking whirlpool baths as an example.

[4] Ebersold, M.; Weber, L.; Öhler, S.; Blau, M.: Trennung von Körperschall- und Luftschallübertragung bei haustechnischen Anlagen. Diploma thesis, Fraunhofer-Institute for Building Physics, Stuttgart / Fachhochschule OOW, Oldenburg, 2008.

[5] Ebersold, M.; Weber, L.; Öhler, S.; Blau, M.: “Effect of airborne sound on installation noise – Part 1: Basic investigations”. Poster presentation NAG/DAGA 2009.