Side effects of the ISO tapping machine as a walking noise source

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Introduction

Walking noise occurs in a room, when a person is walking there. The reason for dealing with walking noise is that there exist very different kinds of floor coverings with very different sound radiation efficiencies. In particular very loud floor coverings can disturb people working in the same room. In France a standard had been prepared to constitute a method to measure walking noise [1]. A CEN working group (CEN TC 126, WG 1, AHG 7) was mandated to write a standard about walking noise measurement in laboratories, which should work with all types of floor coverings. Based on previous investigations of Ann-Charlotte Johansson and on the French standard, it was decided to keep the ISO standard tapping machine and the ISO 140-1 test facility [2], in particular the standard floor, as principal components of the measurement. The A-weighted sound power level in the source room should be determined, corrected for noise from the tapping machine ("self noise") and for the individual characteristics of the lab floor under the floor covering under test. The standard tapping machine obviously seemed to be the biggest problem of the method: on the one hand it produced in many cases too much noise itself and on the other hand, its enclosure shielded the sound radiated from the floor covering. This was the starting point for investigations of the influence of the standard tapping machine on walking noise measurements.

Effects contributing to walking noise

Walking noise is a combination of several effects (Figure 1). One of them is the excitation of structure borne sound, when the walker's shoe hits the floor. This will not only cause the shoe to radiate sound but also the floor covering and the bare floor below it. None of these three parts normally can be neglected. The structure borne sound excitation of shoe and floor depends on the ratio of their mechanical impedances Z.

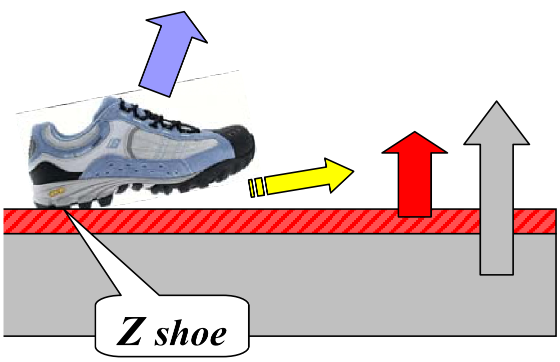

Figure 1: Effects contributing to walking noise on a floor.

Sound is also radiated by the displacement of the air, when the shoe approaches the floor surface, an effect similar to clapping hands. Not only the stiffness of the floor but also the porosity or flow resistance of the floor covering will influence this part. Using an ISO standard tapping machine to measure walking noise characteristics of floor coverings necessarily implies ignoring radiation from shoe and more or less from air pumping.

Shading effect

For laminate floorings it was found out earlier, that most of the radiated sound power originates from an area of a few centimetres diameter around the point of excitation. It was supposed, that tapping machines would influence the radiation of the flooring by their close-by vicinity. Therefore, an accordingly small loudspeaker was mounted flush into the floor of a hemianechoic chamber (Figure 2) and its sound power determined with different tapping machines placed over it or with no tapping machine present.

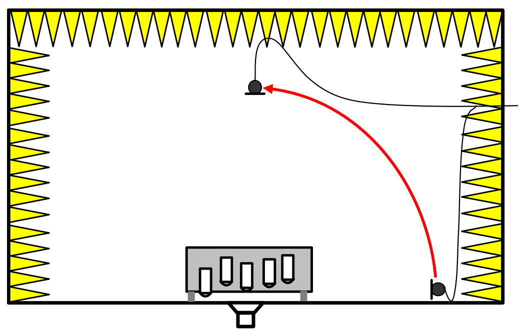

Figure 2: Setup for shielding effect measurements in a hemi-anechoic room. Loudspeaker flush with the floor.

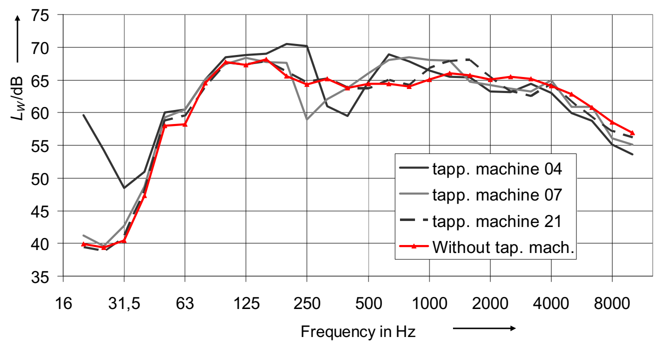

Figure 3: Sound power level of a loudspeaker acc. to Figure 2 without respectively with different standard tapping machines placed over it.

The electric input of the speaker was kept constant in all cases. The results are shown in Figure 3. Shielding and standing wave effects mainly occur between 125 and 2000 Hz, causing a scatter of about ± 5 dB. Transferred to typical walking noise spectra of floor coverings, deviations of up to 2.3 dBA could be expected. "Open" tapping machines disturb least.

Self noise

Self noise on a very rigid floor

Standard tapping machines do not only cause the floor under test to generate noise, but they also produce noise by themselves ("self noise") either by mechanical action or by reacting to the floor, when hitting it, or, in particular situations, by sound transmission into the floor via its feet. The floor induced part of the self noise often predominates. Thus self noise of tapping machines has to be measured under test conditions, i.e. while acting on the particular floor under test, however under avoiding any sound radiation of the floor.

A first realisation of a silent floor with approximately correct input impedance consisted of a concrete block with five small hammer hitting areas sticking out of the block. It was then sunk into the floor of a hemi-anechoic room and covered by a chipboard plate except from the hammer hitting areas (Figure 4). Though looking very promising, the setup showed problems at low frequencies, which seemed hard to solve. During the experiments, the very rigid floor of the hemi-anechoic room proved to be much more silent than the

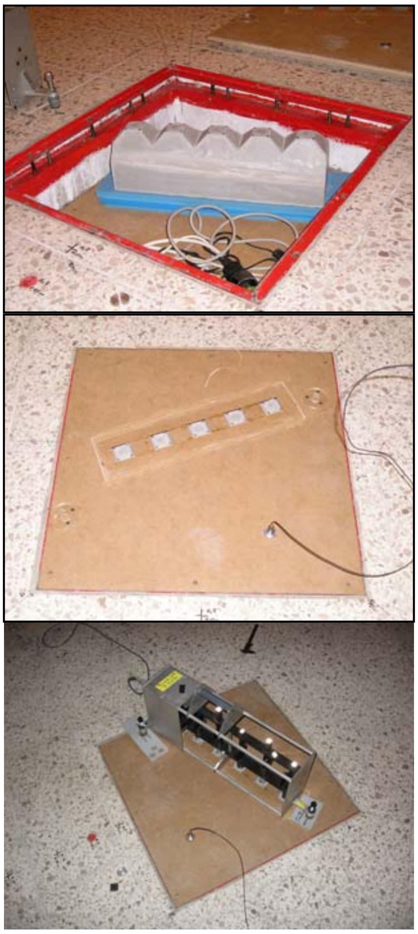

Figure 4: From top: concrete floor mock-up; hidden in the floor cavity - hitting areas visible; with tapping machine.

special block setup, so it was used instead. Self noise measurements of two very different tapping machines - an open and a closed one - and an impact hammer were carried out just by placing five small tabs of the particular floor covering below the hammers (Figure 5). The unwanted bare floor noise was checked with an impact hammer, which because of its small dimensions radiates much less self noise than the tapping machines, at least at low and medium frequencies. The sound pressure level of the impact hammer was corrected for the structure borne sound level difference between impact hammer and tapping machines on the bare floor.

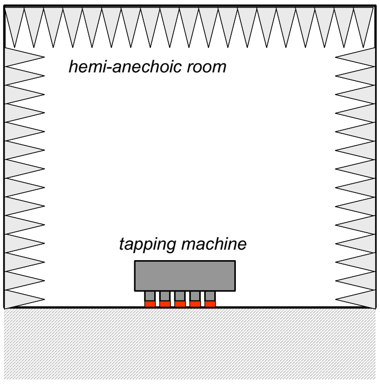

Figure 5: Self noise measurement on a very rigid floor. Red: tabs ob the flooring material under test.

Figure 6 shows the influence of the floor type on the self noise of one of the tapping machines as an example. If the bare floor is included as an example of very rigid floor coverings the scatter of the self noise amounts to 10 dB around 100 Hz up to 40 and more dB above 3 kHz. Figures 7 and 8 show examples of self noise of one of the tapping

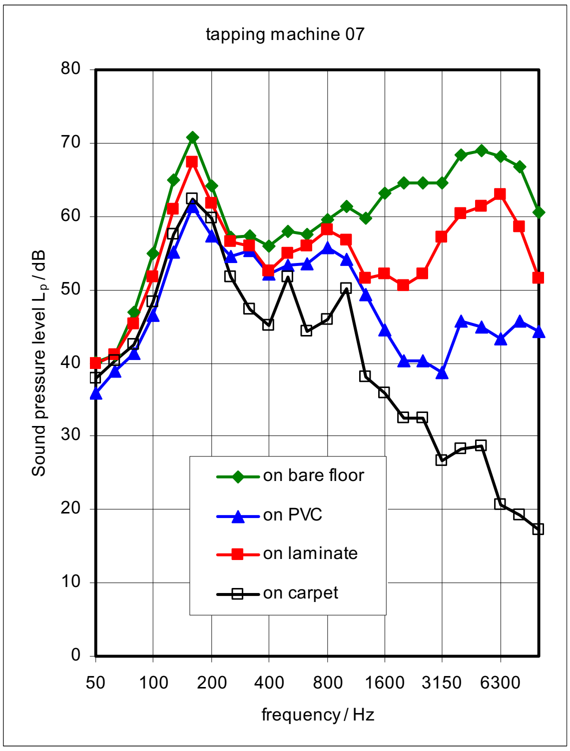

Figure 6: Influence of flooring type on self noise.

machines on laminate flooring respectively carpet. The self noise spectra are compared with the respective walking noise spectra of the floor coverings, by simply replacing the small flooring pads by specimens of the same material but of about

1 m² size. While the laminate flooring seems to be loud enough to predominate the tapping machine, there is only a very little difference between self and walking noise in the case of the carpet. It should be kept in mind, that with this method of self noise determination, the air clapping effect of the hammers is considered as part of the self noise of the tapping machines.

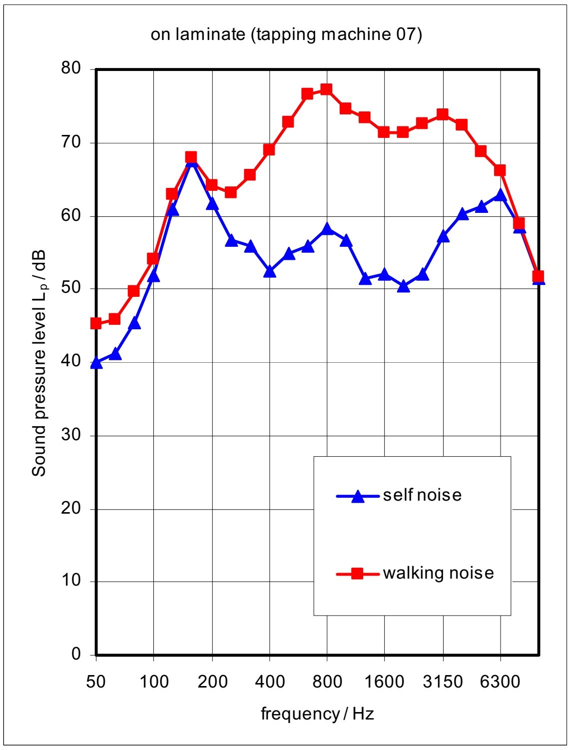

Figure 7: Self noise and walking noise on laminate above a very rigid floor.

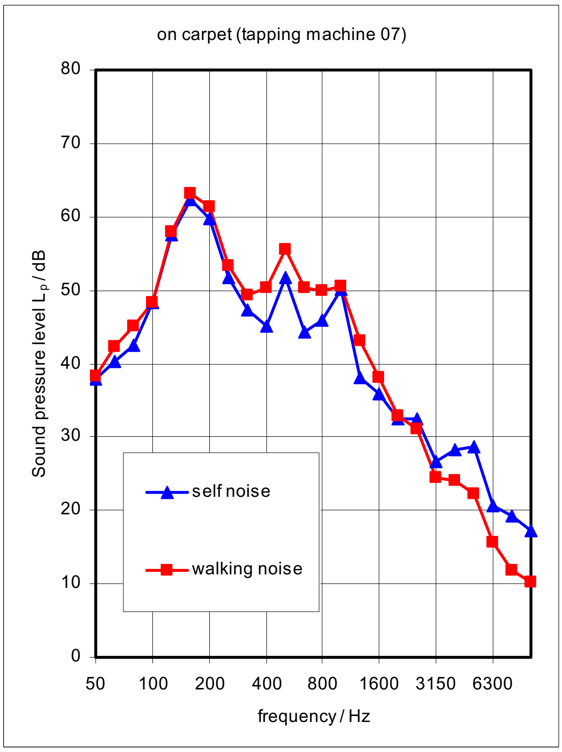

Figure 8: Self noise and walking noise on carpet above a very rigid floor.

Self noise on the ISO 140 standard floor

In the next step, the same kind of measurement was repeated in a test facility for impact sound improvement measurements acc. to ISO 140 [2,3]. Again, the tapping machines were first situated above five pads of the respective floor covering material and then situated on a larger piece of about 1 m² of this material to include the totally radiated sound power of the floor coverings. This way the actual self noise of the tapping machine together with its clapping effect and the radiation of the bare floor were included in the resulting sound power levels. This is shown in Figures 9 and 10. For comparison, the results are shown together with the respective self noise and walking noise sound power levels determined earlier on the rigid floor of the hemi-anechoic room. From Figure 9 it can be seen, that with PVC floorings for example, there is not much difference between the self noise and the walking noise results neither on the rigid hemi-anechoic room floor (HAR) nor on the ISO standard floor (ISO). The fact, that the ISO results lie about 10 dB above the HAR results at frequencies below 1600 Hz, demonstrates that the radiation of the ISO bare floor predominates in this area. At higher frequencies the self noise directly from the tapping machine seems to prevail. Figure 10 shows the results for the alike measurements with laminate floor coverings. In this case the test object seems to control the total sound power level at least between 300 and 6300 Hz. Below 160 Hz again the ISO standard floor radiation dominates.

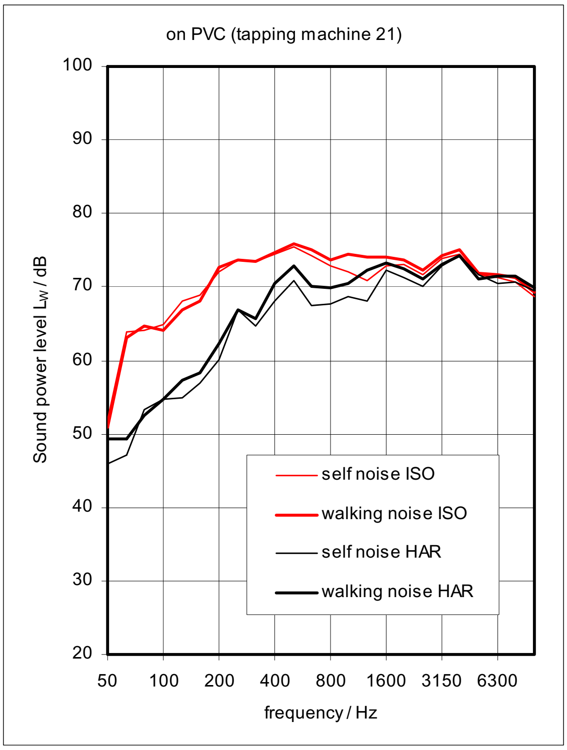

Figure 9: Self noise and walking noise on PVC above an ISO standard floor (hemi-anechoic room measurements on a rigid floor for comparison)

During the measurements on the ISO 140 standard floor the acceleration level of the floor was controlled at a measuring position at 1 m distance. Figure 11 shows the results for both tapping machines and the impulse hammer. The spectra of the tapping machines show sufficiently good agreement below 1000 Hz, but a considerable discrepancy above. An explanation has not yet been found. The spectrum of the impact hammer looks quite different, however. It is assumed that this is due to two reasons: (1) The impact hammer has a much smaller contact area (diameter < 1 cm) than the tapping machine (diameter = 3 cm), i.e. the pressure of the impact hammer is higher for the same structure borne sound excitation. This indicates the presence of non-linear effects. (2) The impact hammer has a smaller mass than each of the tapping machine hammers. This would indicate, that the interaction of source and receiver impedance is not negligible. Both reasons would be even more important when regarding walking persons compared with the standard tapping machine.

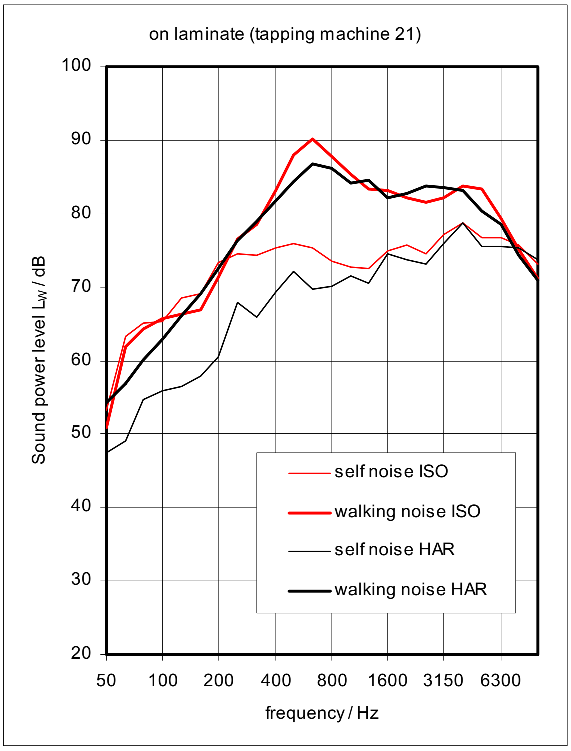

Figure 10: Self noise and walking noise on laminate above an ISO standard floor (hemi-anechoic room measurements on a rigid floor for comparison).

Summary and conclusions

Using standard tapping machines for walking noise measurements on different floor coverings means a compromise. This would neither represent sound from the shoes nor sound from the clapping effect (or air pumping) between shoe and the floor in a way close to the real situation. Because of the difference between walker and a tapping machine in the magnitude of the exciting pressure, soft floors with non-linear behaviour may produce untypical results with the tapping machine. Also the source impedance will play an important role in the generation of walking noise on floor coverings.

Apart from this, two effects of the tapping machines were investigated in more detail: (1) Tapping machines shield the noise radiation from a floor. This influence reached up to 2.3 dBA for a machine with enclosure and a little bit less for the open machine tested. (2) The second effect is the self noise of the tapping machines. Among three floorings tested - PVC, laminate and carpet - only the laminate floor was loud enough to prevail the tapping machine self noise. Fixing small pads of the material of interest on a very rigid low noise floor and letting the tapping machine hammer on them seems to be the easiest way to assess self noise. Because of the big influence of the floor covering, self noise has to be stated in each case. Worst case estimations seem useless.

On ISO standard floors noise from the bare floor predominates the radiated walking noise at low and sometimes even medium frequencies.

Impedance matching and non-linearities are suspected to be the reasons of some unclear effects. A Round Robin test should be carried out to affirm the applicability of the tapping machine for walking noise measurements.

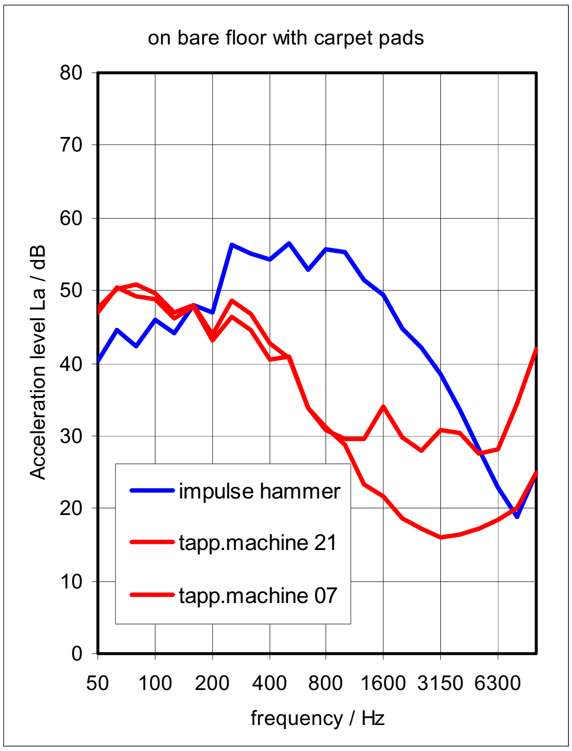

Figure 11: Structure borne sound input of different sources into the ISO floor via the carpet pads.

References

[1] NF S 31-074: Acoustics - Measurement of sound insulation in buildings and of building elements - Laboratory measurement of in room impact noise by floor covering put in this room.

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

[3] ISO 140-8:1997: Acoustics - Measurement of sound insulation in ... - Part 8: Laboratory measurements of the reduction of transmitted noise by floor coverings on a heavyweight standard floor