Measurement of waste water noise according to EN 14366

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Introduction

Measurements in laboratory are an useful tool for the acoustical characterisation of waste water systems and can help to avoid noise annoyance in buildings. The measuring method is defined in the European standard EN 14366 [1], introduced in February 2002. The main differences of the new standard compared to the previous method (developed by the IBP, not standardised) are:

- Separation of the waste water noise into an airborne and a structure-borne component.
- Normalisation of the measuring results with respect to a fictitious reference wall with m'' = 250 kg/m^2 by means of the structural sensitivity of the test wall.

In the following the principles of the measuring method are explained and practical experiences and problems are reported.

Principle of measurement

The measurements are carried out in a test facility, which consists of two rooms separated by an installation wall. The system under test is fixed to the installation wall and fed by a constant flow of water (0,5, 1,0, 2,0 and 4,0 l/s). The measuring arrangement is shown in Figure 1:

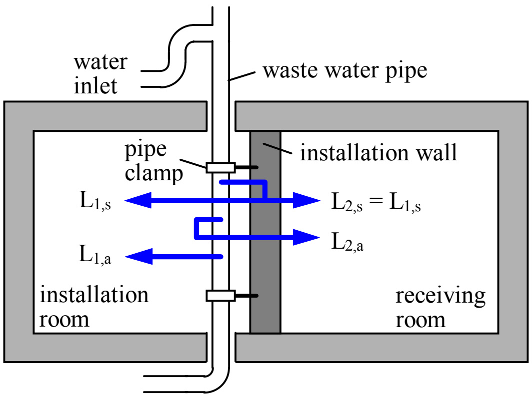


Figure 1: Test facility for measurement of waste water noise. The arrows describe the various components of noise generated by the waste water system. The meaning of the indices is: 1 = installation room, 2 = receiving room, a = airborne sound, s = structure-borne sound.

Waste water systems cause airborne and structure-borne sound, which - depending on the particular building conditions - differently contribute to the resulting noise level. That's why airborne and structure-borne are determined separately. For this purpose first a measurement with closed pipe clamps is performed, which provides the levels $L_{1,closed}$ and $L_{2,closed}$. Then the clamps are opened, so that the pipe is disconnected from the wall. The level $L_{2,open}$, measured in this state, is only due to the airborne sound radiated by the pipe. From the measured values the relevant noise components, $L_{2,s}$ and $L_{1,a}$, can be calculated by:

$$L_{2,s} = L_{2,closed} \varnothing L_{2,open}\,, \tag{1}$$

$$L_{1,a} = L_{1,closed} \varnothing L_{2,s}\,, \tag{2}$$

where $\varnothing$ denotes the energetical subtraction of levels. Next the noise component $L_{2,s}$ is normalised by:

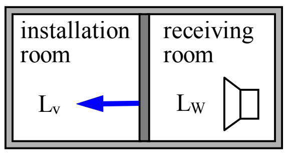
$$L_{2,s,ref} = L_{2,s} - L_{\alpha,T} + L_{\alpha,R}\,, \tag{3}$$

where $L_{\alpha,T}$ and $L_{\alpha,R}$ are the structural sensitivity levels of the test wall and the reference wall (the meaning of these terms is explained below). Finally the spectra are A-weighted and normalised to an equivalent absorption area of A = 10 m^2. The calculation of single number values is performed by energetical addition of levels between 100 and 5000 Hz.

Structural sensitivity

The structural sensitivity level $L_{\alpha,T}$ describes the acoustical response of the test wall to point excitation. It is defined as normalised ratio between the exciting force and the resulting sound power radiated by the wall. The determination of $L_{\alpha,T}$ is carried out according to Equation (3) and Figure 2:

$$L_{\alpha,T} = L_v - L_W + [10 \lg(V_2/T_2) - 25]\ \mathrm{dB}\,. \tag{4}$$



L_v = velocity level at the position of the pipe clamp
L_W = sound power level emitted into the receiving room
V_2 = volume of the receiving room in m^3
T_2 = reverberation time in the receiving room in s

Figure 2: Determination of the structural sensitivity of the test wall using the principle of reciprocity.

Results

Calibration of the test wall

The calibration of the test wall is performed by measuring the structural sensitivity level at the position of each pipe clamp and energetically averaging the results. In Figure 3 measurements on three different walls are shown. Although the walls are equally constructed, there is a strong fluctuation of the measured values, even if the measurements are carried out at adjacent positions of the same wall.

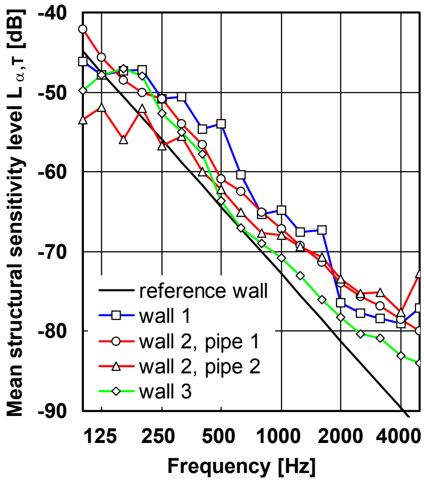


Figure 3: Mean structural sensitivity level of three different test walls. The walls had the same construction (115 mm solid lime sand stones plastered on both sides) with a mass per unit area of about 220 kg/m^2.

Another problem concerning the calibration of the test wall is, that the spatial averaging of the structural sensitivity is only useful, if the forces transmitted into the wall via the clamps are equal. In practice, however, this is often not the case, since the force strongly depends on the adjustment of the clamps and on their position along the pipe (distance from sleeves, inlets and bends). Tightening the screws of the clamps by only a small amount can change the force level by several dB. This is one reason for the poor comparability of the measured values. Furthermore the calibration procedure only considers perpendicular forces, whereas in-plane forces and bending moments, which also contribute to the excitation of the wall, are not detected.

Separation of airborne and structure-borne sound

For separation of airborne and structure-borne sound Equations (1) and (2) are used. In case of the airborne sound radiated by the pipe, $L_{1,a}$, the application of Equation (2) normally doesn't cause a noticeable change (i. e. $L_{1,a} \cong L_{1,closed}$), since for solid installation walls and elastic clamps the sound radiation of the pipe is much stronger than that of the wall. This is confirmed by Figure 4, which shows input values and result of the calculation.

The structure-borne sound component emitted into the receiving room, $L_{2,s}$, is calculated by Equation (1). The calculation is carried out in the same way as the correction for background noise according to DIN EN 20140-3 [2]. This means, that the calculated value of $L_{2,s}$ can be at most 1,3 dB lower than the measured sound level in the receiving room, $L_{2,closed}$ (the limit is reached when the difference between $L_{2,closed}$ and $L_{2,open}$ becomes less than 6 dB).

Comparison between old and new method

A comparison between the results of EN 14366, $L_{1,a}$ and $L_{2,s,ref}$, and of the previous measuring method, $L_{1,closed}$ and $L_{2,closed}$, is shown in Figure 4. Concerning the airborne sound in the installation room there is almost no difference between the two methods. In case of the structure-borne sound transmitted into the receiving room EN 14366 normally yields smaller values of the sound level. The difference, $L_{2,closed}$ - $L_{2,s,ref}$, lies between –0,6 and 5,2 dB. The main reason for this difference is not the separation of the airborne sound, which contributes by at most 1,3 dB, but the normalisation of the results with respect to the reference wall.

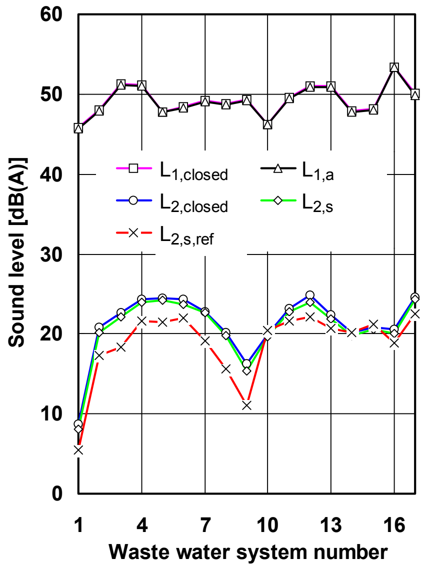


Figure 4: Airborne and structure-borne sound level of seventeen waste water systems (A-weighted sum level normalised to A = 10 m^2). Application of EN 14366 yields $L_{1,a}$ and $L_{2,s,ref}$ as final results. The levels $L_{1,closed}$ and $L_{2,closed}$ are the results of the previous measuring method and also serve as input values for EN 14366.

Summary

The European standard EN 14366 introduce a new measuring method for waste water noise in laboratory, which provides reproducible and comparable results. In addition it principally allows the transfer of laboratory values to other building situations. Unfortunately the method is rather complicated, so that it is difficult to understand without acoustical knowledge. This can cause practical problems, since wrong or incomplete results are used in advertisement and technical documentation. For use in acoustical planning it must be considered that EN 14366 separates airborne and structure-borne noise, whereas the requirements of DIN 4109 refer to the sum of both contributions. Furthermore the new measuring method contains some systematic sources of error, which may affect the accuracy of the results. To check the reliability of EN 14366 interlaboratory tests are required.

References

[1] DIN EN 14366 (2002, draft): Laboratory measurement of noise from waste water installations. Beuth Verlag, Berlin.

[2] DIN EN 20140-3 (1995): Laboratory measurements of airborne sound insulation of building elements. Beuth Verlag, Berlin.