Reference level in ISO 3382 parameters: G, ST, L and STI

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Introduction

In the room acoustic parameters Sound Strength (G, L_J), Support (ST_{early} and ST_{late}) as described in ISO 3382-1 and parameters $L_{p,A,S,4\ m}$ and STI as described in ISO 3382-3, a reference sound level is part of the parameter definition. For most parameters, a laboratory sound power calibration is required. Different types of laboratory calibration methods are described in ISO 3382-1, but research has shown that they may yield different results. In the ST parameters, for every single measurement an attempt is made to determine the free field sound level at 1 m distance by windowing. Some researchers and engineers have investigated the possibility of using such in situ reference measurements for all parameters, to avoid the necessity of laboratory calibration. However, there seems to be little agreement on which method is most accurate, most reproducible and at the same time sufficiently practical. In this paper, the figures as presented on the DAGA conference poster are explained. Differences and uncertainties in methods are discussed.

Measurements

The sound power level of a dodecahedron sound source B&K type 4292 has been studied using various methods. The starting point is a sound power measurement in the reverberation room, because both noise and impulse responses can be used following ISO precision methods and following ISO 3382-1. Furthermore, the sound power was determined using a:

- reference sound source in a reverberation room;
- sound intensity measurement in an anechoic room;
- sound level measurement in the anechoic room at 1 and 7 meter distance from the source either using noise or impulse responses (see figure 1 and 2);
- sound level measurement on a concert hall stage at 1 meter distance from the source either using noise or impulse responses (see figure 1 and 2).

In figure 3, all of the used methods are depicted using photographs. In case of the impulse response measurement on stage, the sound power was determined both with a 0-10 ms time interval and a 0-inf time interval (where infinite is the cross-point between the decay and the noise level).

The difference between each sound power measurement was calculated for 4 different single number ratings:

Low	= average 125 and 250 Hz
Mid	= average 500 and 1000 Hz
High	= average 2000 and 4000 Hz
Mid2	= average 250 to 2000 Hz*

*typical range for the support parameters

In figure 3, the difference in measured sound power level between the various methods is presented for the single number ratings. The arrows indicate an increase in sound power level from one to the other method. For instance, a +1.3 dB increase in sound power level is measured in the frequency band rating ‘Mid’ when measuring on a concert hall stage using a noise signal instead of a measurement in the reverberation room using the same signal. When using impulse responses and a 0-10 time interval, this difference is +0.3 dB for the same frequency range.

Besides the differences in methods, the repeatability and/or reproducibility of some of the methods are presented in figure 3. For instance, the standard deviation of 10 repeated sound power measurements in a reverberation room on a dodecahedron B&K type 4292 using a noise signal, over a 4 year period, is 0.2 dB for the Mid frequency range average.

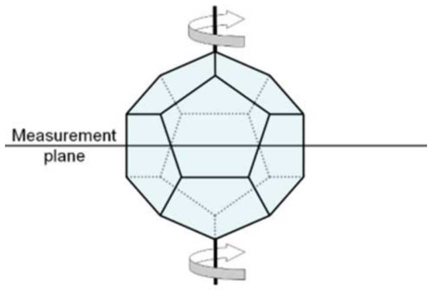

Figure 1: Anechoic and in situ measurements are done in the horizontal plane of the dodecahedron sound source. For measurements using a broadband noise signal, an average was taken over a full rotation, denoted ’**full rot**‘. For measurements using impulse responses, a rotational average of 8 equal angular steps was used, denoted ’**8 step**‘. Figure 2 shows that the uncertainty due to loudspeaker directivity is reduced to less than 0.1 dB when using the 8 equal-angular step average.

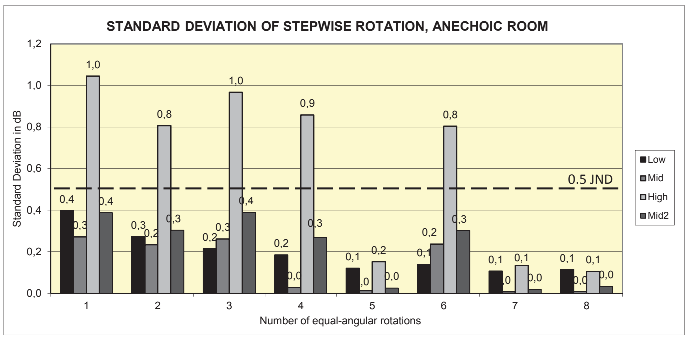

Figure 2: The standard deviation for single measurements (1 random step) and for an average over multiple steps (2 to 8 equal-angular steps), derived from 72 measurements with 5 degree rotation of a dodecahedron sound source in an anechoic room at 7 m distance from the microphone.

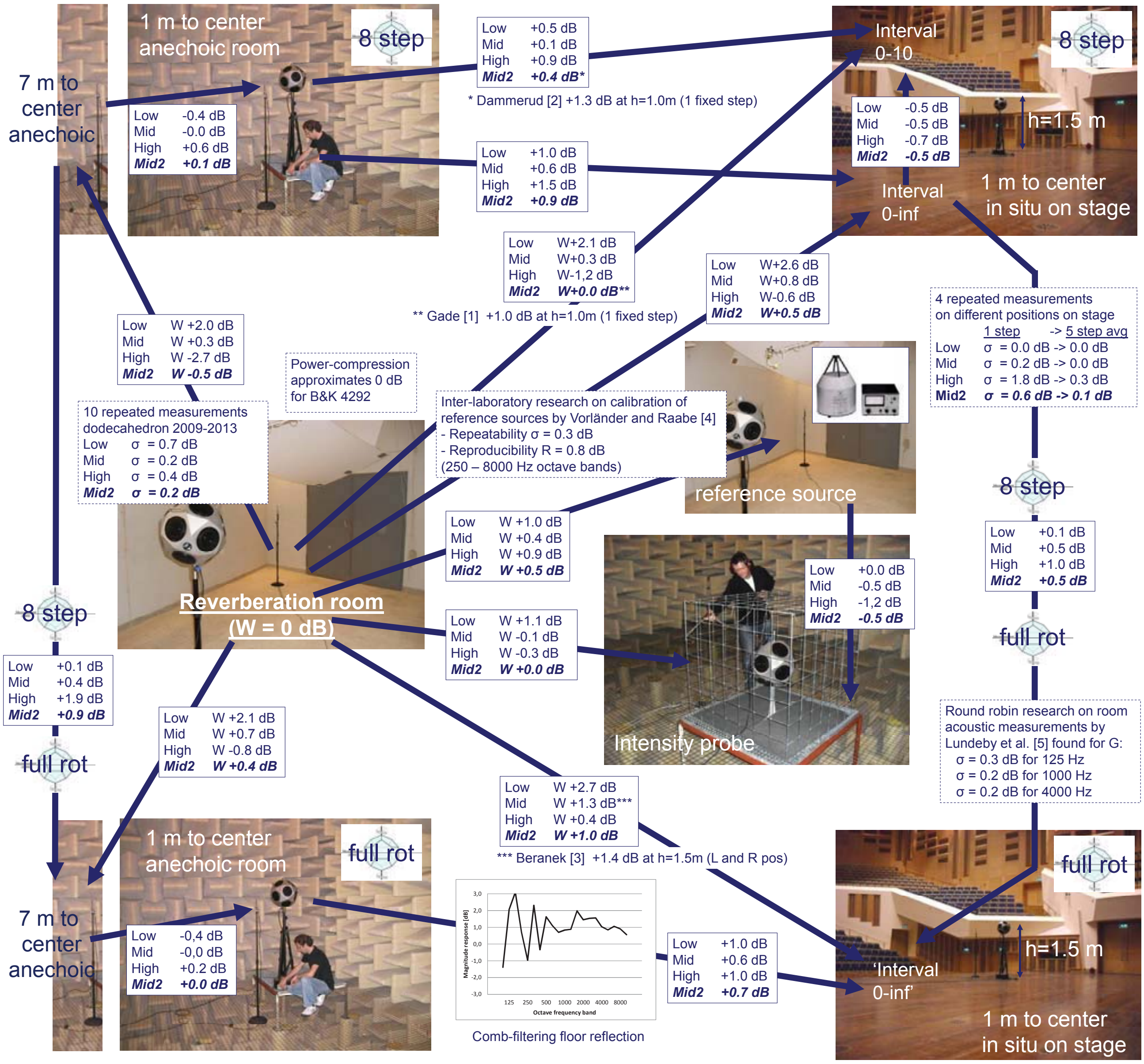

Figure 3: Overview of measurement results (see section 'Measurements' for further explanation)

Discussion

The results show that, for this specific omnidirectional sound source, the variation in measured sound power level in the Mid and Mid2 rating is within 0.5 dB for the reverberation room methods and the intensity measurement. These differences are within the same order of magnitude as the repeatability and reproducibility of measurements on a reference sound source using all these methods [4]. For the Low and High rating, a difference up to 1.2 dB is found between the three precision methods.

For the anechoic room measurement performed in the horizontal measurement plane, either using noise or impulse reponses, the maximum difference from the reverberation room method in the Mid and Mid2 ratings is 0.7 dB. However, in the Low and High rating, differences are larger up to 2.7 dB. It is interesting to note that the measurement results at 1 and 7 m distance are very similar.

The measurement results on stage show that the difference between a laboratory and an in-situ calibration cannot be neglected and, compared to those presented by other researchers, varies for each different measurement setup.

Literature

[1] Gade, A.C.: Acoustical survey of eleven european concert halls. TU Denmark report 44 (1989)

[2] Dammerud, J.: Details on G versus ST as a measure of absolute acoustic levels. Online white paper (2011)

[3] Beranek L.: Concert Halls and Opera Houses, second edition, Springer, New York (2004)

[4] Vorländer, M. and Raabe, G.: Calibration of Reference Sound Sources. Acustica 81 (1995)

[5] Lundeby A. et al.: Uncertainties of Measurements in Room Acoustics. Acustica 81 (1995)