BACKGROUND NOISE LEVEL MEASUREMENTS WITH AND WITHOUT AUDIENCE IN A CONCERT HALL

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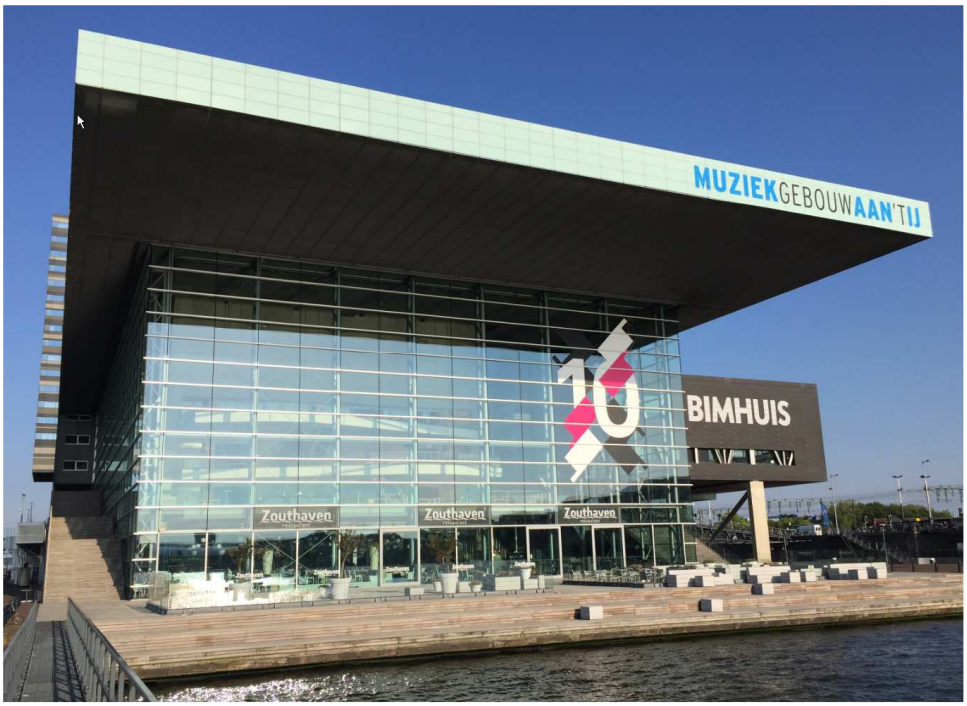
1 INTRODUCTION

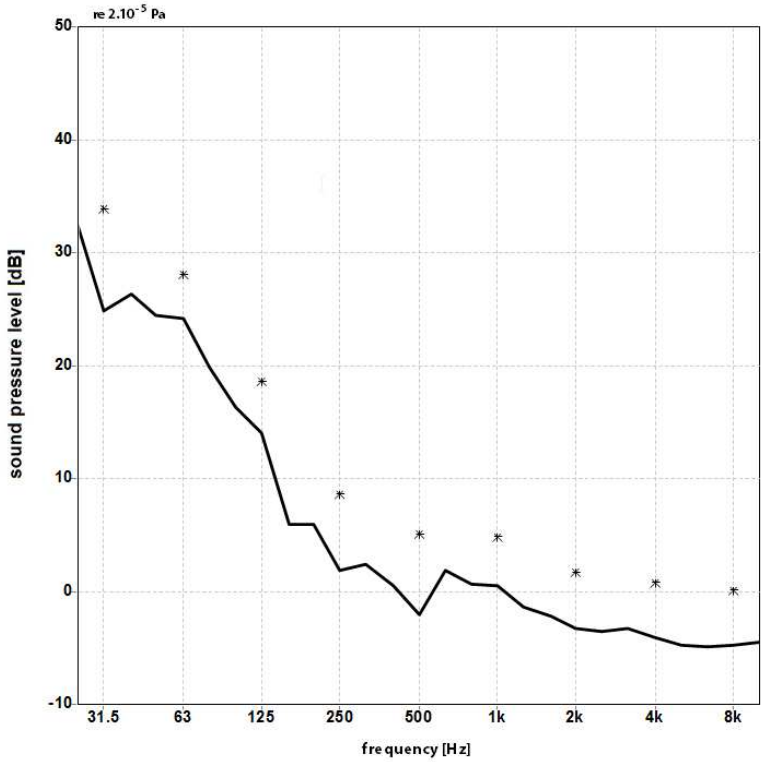
In the design of concert halls it is important to know what degree of silence has to be designed for, in order to achieve a maximum audibility of the most silent passages of the music played. In these considerations not only the experience of musicians plays an important role, but also from the most critical listeners within the audience. For this judgement it is therefore also important to know how silent an audience can behave.
In this study several sound level measurements performed in the Muziekgebouw at the IJ (Amsterdam) will be discussed. This concert hall, consulted by Peutz, opened in 2005 and has 730 seats, with a variable room volume between 7.700 m3 to 11,500 m3 and variable reverberation times between 1,3 to 2,5 seconds, using natural variable acoustics using a movable ceiling.



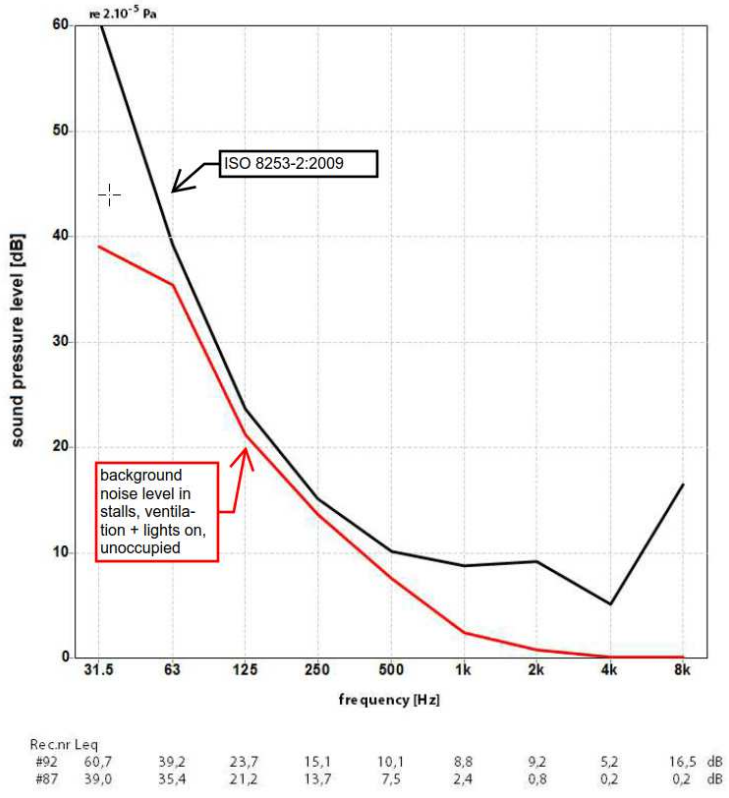
2 MEASUREMENTS

2.1 Background noise levels due to ventilation

In 2005 after delivery of the Muziekgebouw at the IJ, measurements of the background noise level of the ventilation system have been performed in an unoccupied hall to check whether the goal set of 15 dB(A) aimed for was realized. The result was a background level of 13 dB(A) with installations switched on (see next graph with octave band levels measured) and of 11 dB(A) if switched off. Based on this result it could be concluded that this goal had been met.



The background noise level of the ventilation system in the unoccupied hall can be compared with the threshold of hearing (cf. ISO 8253-2:2009), both are given in octave bands in the next graph (measurement (black line), threshold (red).



It can be judged that the background level in concert hall of the Muziekgebouw at the IJ with nominal ventilation in unoccupied condition remains significantly below the threshold of hearing (ISO 8253-2:2009), so the technical installations should be inaudible even for the most critical listener. This is an optimal situation to create a maximum audible dynamic range for listeners to the music performed, as well for the musicians on stage as for the audience in the hall.

Beside the superior acoustics and its variability[1], this quietness of the concerthall has proven to be a significant factor in its success since its opening in 2005.

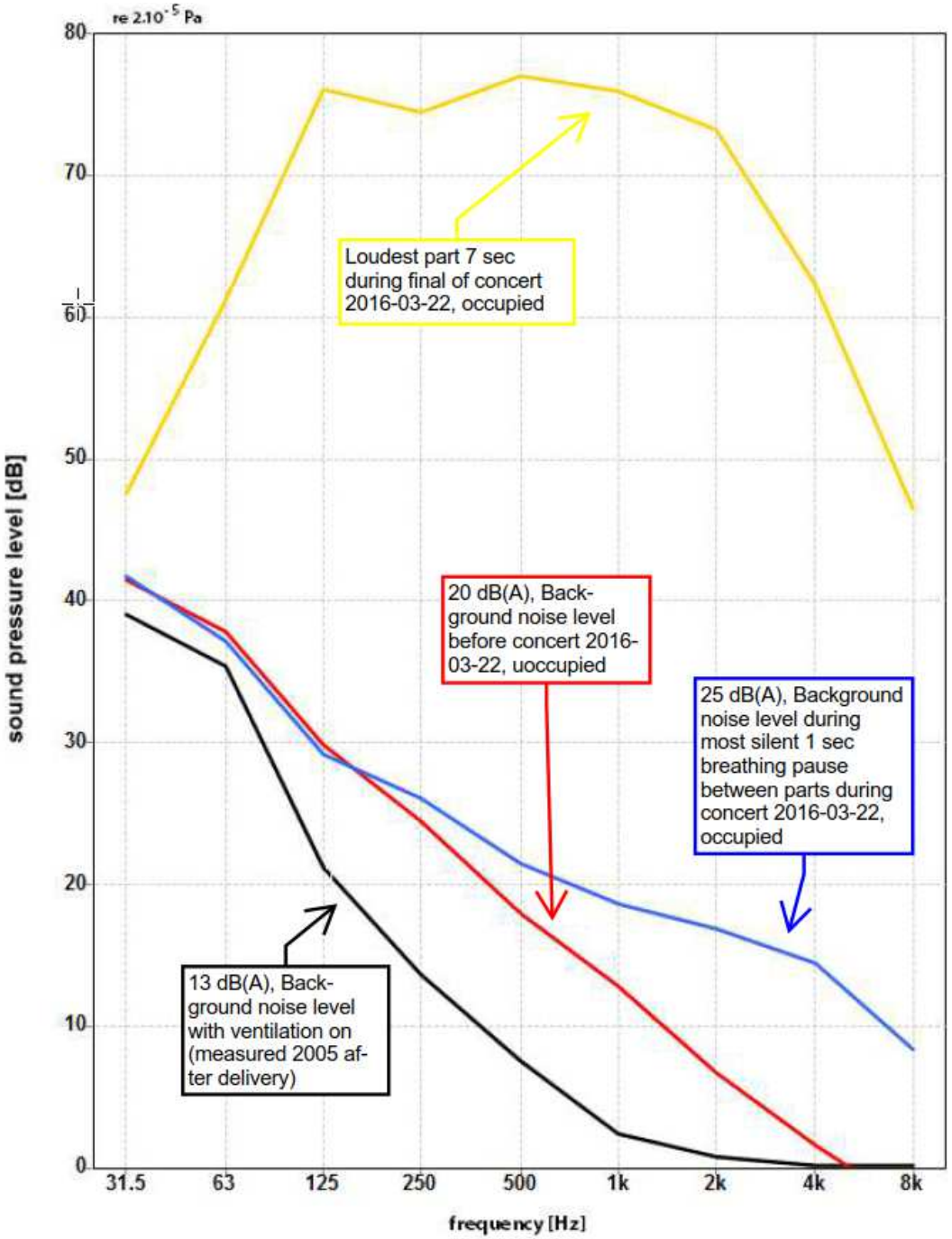
2.2 Background noise levels with audience

However, in order to maintain a large audible dynamic range in the occupied hall, a well behaving and quiet audience is primarily required. In order to obtain more objective data about how quiet a real audience can and will be, it is in our opinion necessary to do measurements in a very silent hall that is more silent than the quietest audience, so the contribution of the audience can be clearly distinguished from other background noise. For that purpose this specific concert hall of the Muziekgebouw at the IJ seemed to be very suitable because it is probably the most silent concert hall within the Netherlands, despite the position of the technical rooms being directly adjacent to the balcony of the concert hall. This silence is mainly achieved by using a full box-in-box construction for the complete concert hall itself, as well by thorough design and advice on the complete ventilation system during all phases of the design and the building process[1].

For the above reasons sound level measurements have been performed in the same concert hall of the Muziekgebouw at the IJ during several classical concerts in the season 2015-2016. The analysis of these measurements is presently ongoing, and the first preliminary results will be discussed further in this article.

For these measurement the same class 0 measuring equipment has been used that was used for the background measurements of the ventilation. This measuring set consists of a class 0 sound level meter Brüel & Kjaer type 2610 with a preamplifier Brüel & Kjaer type 2660 with a 1” microphone Brüel & Kjaer type 4179. Because this set is rather large and non-portable and the first balcony of the concert hall was usually unoccupied, it was chosen to put the measuring equipment on the first rows of the balcony and to hang the measuring microphone down from an extension rod to a suitable measuring position closely above the seated audience on stalls level. In the photo in the next graph the position of the measuring microphone is indicated and the extension rod from the balcony edge is clearly visible.

Several sound levels measured before and during a concert in the concert hall of the Muziekgebouw at the IJ of the Orchestra of the 18e Century together with Cappella Amsterdam on March 22nd 2016 are given in the next figure.



Recnr	Leq									
#87	39,0	35,4	21,2	13,7	7,5	2,4	0,8	0,2	0,2	dB
#56	41,5	37,8	29,8	24,4	18,0	12,8	6,8	1,6	-2,9	dB
#73	41,8	37,1	29,2	26,1	21,5	18,6	16,9	14,4	8,4	dB
#79	47,6	61,2	76,1	74,5	77,0	75,9	73,3	62,3	46,5	dB

2.3 Conclusions and further investigation

From the measurements that are graphically presented in the graph above, it can be concluded that:

- the background level of 20 dB(A) measured in unoccupied condition before the concert is significantly higher than the value of 13 dB(A) as measured in 2005 at the delivery of the ventilation system. Further investigation will have to be done to clarify this difference. Possible explanations could be additional lighting applied, or a different setting of the ventilation system used, or more disturbance due to people involved before the concert on backstage or people around the hall.
- During the most silent moment of this concert in a short breathing pause between two music parts, the equivalent sound level measured over 1 second was 25 dB(A). The graph above shows that for frequencies above 500 Hz this sound level measured was significantly higher than the background level measured before the concert without audience. This indicates that during quiet moments the average quiet audience itself does not produce much sound below 250 Hz, as might be expected for people that are not talking or moving. However the measurement also indicated that in this case even quiet audience still does produce measurable sounds up to 25 dB(A) for frequencies from 500 Hz and higher.
- Further investigation of additional measurements during other concerts will have to be done in order to discover whether lower sound level contributions of audience than this value of 25 dB(A) can be measured. Based on personal listening experience it is expected that this should be possible, because the author has experienced that if everyone within the audience would behave as quiet and would hold their breath simultaneously during a music pause, even an absolute silence can be heard that subjectively could be down to 15 dB(A).
- Based on these measurements an audience contribution of 23 dB(A) can be deduced. If an occupancy of around 500 people is assumed for this concert as well as a average Sabine acoustical room absorption of 870 m2 (based on a large room setting of 11,500 m3 with ca. 2,2 seconds reverberation time (audience + orchestra)), it can be calculated that the corresponding sound power level for this measured situation of a quiet audience is around $L_{w,A}$=19 dB per person. For now it is expected that the natural breathing sound of people might be responsible for a certain minimum level caused by audience, where the specific sound power per person may differ significantly from person to person. Further investigation is proposed on that, possibly under laboratory conditions in an anechoic room or in a reverberation room.

Analysis of more concert measurements and further research with laboratory measurements on sound power of breathing people is foreseen. Therefore it is yet to early to make final conclusions about whether the additional efforts and costs to realize a low background noise level of 15 dB(A) pays off during a classical concert or that such low background noise levels are not worthwhile aiming for in presence of an average audience, or whether a background noise level of 20 dB(A) or higher could also be sufficient.

3 REFERENCES

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