ACOUSTICS IN HALLS FOR ROCK MUSIC

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ABSTRACT

Acoustic measurements have been carried out in seven Danish halls used for rock music. The halls with capacity ranging from about 400 to 1200 people are all frequented by major Danish and international acts. The project aimed at finding specific room acoustical design criteria which will ensure good conditions for rock and other forms of rhythmic music heavily depending on the use of PA and monitoring loudspeakers.
The measurements concentrated on T30, EDT, C80, and D50 and were made according to ISO 3382. In most cases measurements were carried out using an omni directional loudspeaker as well as the house PA systems installed in each of the halls.
The analysis of the data was focused on finding possible relationships between the perceived and measured acoustics on stage and between the acoustics on stage and in the audience area.
One often encountered acoustic problem in the halls was high T30 values and low clarity/definition at low frequencies. The results are in agreement with a subjective rating list also made in the investigation.

1. INTRODUCTION

1.1. Background

Among audience and performers alike it is a well known fact that to a large degree bad acoustics can ruin the joy of a musical performance. As a matter of fact both performers and audience sometimes choose not to go to a venue because of unsatisfactory acoustical conditions.
Halls for classical music seem to benefit from years of acoustical research. There is a long tradition as seen in numerous books and articles as to explain acoustics in these halls. It seems fair to bring more attention to halls for popular music since, as a quick estimate at least half of all concerts offered are within the genres of contemporary popular music: Rock, Pop, Jazz, Latin etc.
In spring 2003 the two of the authors of this project participated in the course Architectural Acoustics at DTU, the Technical University of Denmark. As a project, a concert hall for popular music was modeled (with the guidance of Anders C. Gade and Jens Holger Rindel). This raised a debate on how to define good acoustics in halls for this purpose.
As the first author of this paper is also a musician having played well over 1000 concerts in the relevant kind of halls, motivation and background was at hand for an investigation to cover this area more in depth.
Only very few halls are built specifically for rock concerts. Most often abandoned halls such as old cinemas or industrial buildings find a new life serving contemporary music performances. Two of the seven halls being

investigated in this paper have been built recently as multi purpose halls. Often the hall volumes are excessive and thus need extensive acoustical treatment.

1.2. Musical genre

One obvious thing that characterizes popular music performances is the use of powerful PA systems. The SPL at rock concerts will often be well beyond 100 dB in the center of the hall several meters from the stage. But also on stage the sound sources are radiating SPL of this magnitude in the frequency range of 40 Hz to 10 kHz towards the performers. Consequently it is clear that the final quality of sound in a certain hall depends on the sound system and on its coverage of the hall.
On stage the performers want some early reflections from walls, floor and ceiling of the stage area. In particular this is true for acoustic performances such as acoustic jazz trios. Reflective surfaces will give the musicians a sensation of being connected in a natural and relaxed way. They are not so much interested in late reflections from for instance the back wall. Especially drummers and other musicians playing instruments of short percussive sounds can have difficulties "navigating" in a sound field dominated by late energy. The excessive use of PA in front of the stage combined with a long reverberation time in low frequencies seems to provoke this acoustic problem.
Nevertheless a certain amount of support from the audience area of the hall is necessary. Too little is a source of irritation, the performer gets a feeling of not reaching the audience since he/she does not get a good sense of "being heard" nor of the response of the audience. The ideal reverberation time seems to lie within a certain "tolerance" range. If it is too long - i.e. if late energy dominates - it brings some difficulties to the performance and if it is too short, timing differences between the musicians will appear extra obvious and can minimize the confidence among the musicians.
Audience and especially sound engineers like a precise clear sound. One would think that a very short reverberation time could be the answer to this desire. But the audience may also perceive this as a lack of vivacity, and it is also unclear whether audience and performers will agree regarding optimal reverberation times. Will performers lack support, if it is very short?

2. MEASUREMENTS

Based on the first author's experience as a performer and the experience of Pelle Giøbel as a sound engineer and qualified listener, seven Danish concert Halls were rated subjectively from 1 – 3 with 3 being above average. Afterwards, objective measurements were carried out in these halls (in unoccupied condition).

	hall-rating	stage-rating	volume [m3]	listener capacity
Amagerbio	3	3	4500	1200
Pumpehuset	3	2	3000	600
Slagelse	1	1	3800	700
Stars	3	2	1440	400
Tobakken	2	1	6500	1200
Train	3	3	3300	1000
Viften	1	1	3950	700

Table 1. Rating list and geometrical features of halls.

The guidelines of ISO 3382 were followed regarding impulse response measurements and parameter calculations. Normally eight receiver positions were chosen among which two were placed on the stage to represent performers' listening positions.
The software DIRAC was used to obtain the impulse responses. Linear sweep of 5.5 Sec. duration was used as measuring signal and 5 averages were made in each measurement position.
The same dodecahedron source placed center stage was used in all the halls. Besides, the influence of the house PA system on the acoustics was investigated by also using these (including stage monitors where available) as an alternative sound source.

3. RESULTS

The main measurement results are summarized in Figures 1 – 4 and Table 2 below.

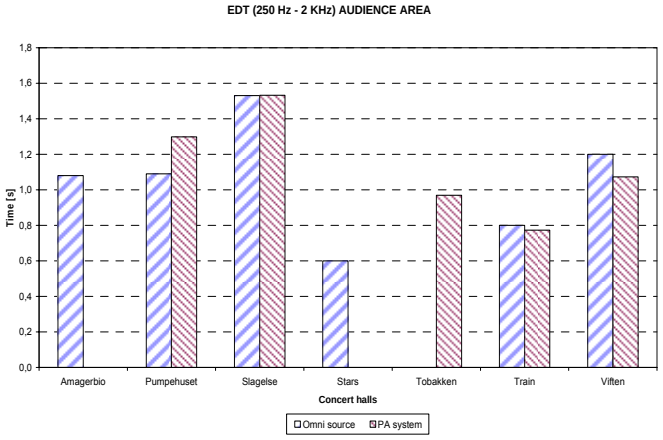

Figure 1. EDT comparison when measured with PA and omni source in the range of 250 Hz – 2 KHz.

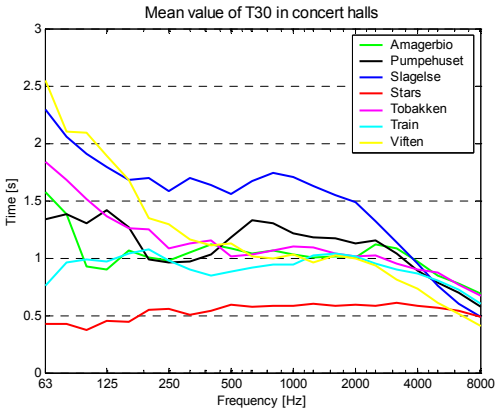

Figure 2. Position averaged T30 per 1/3 octave in all halls. NB: Tobakken and Viften were measured with PA.

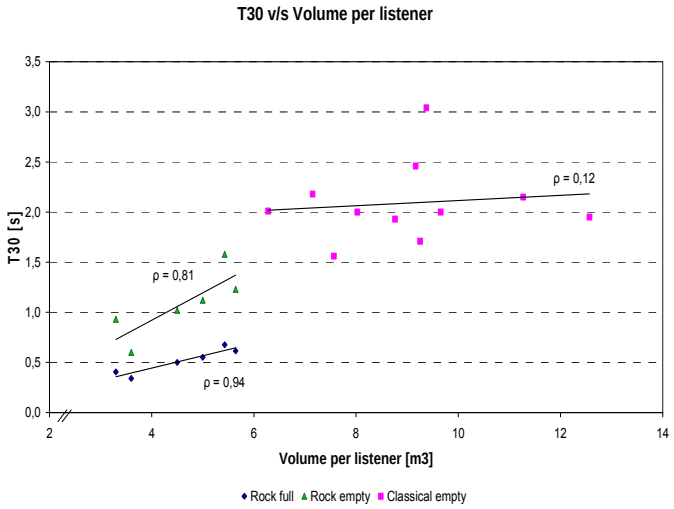

Figure 3. T30 (250-2000 Hz) v/s volume per listener for rock and classical concert halls.

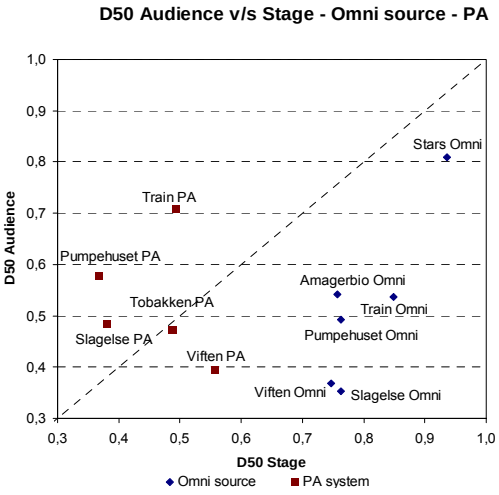

Figure 4. D50 (63-250 Hz) for audience and stage area measured with PA and omni source.

BR	$\frac{T30_{63Hz}+T30_{125Hz}+T30_{250Hz}}{T30_{500Hz}+T30_{1kHz}+T30_{2KHz}}$	$\frac{T30_{125Hz}+T30_{250Hz}}{T30_{500Hz}+T30_{1kHz}}$
Amagerbio	1,2	0,9
Pumpehuset	1	1
Slagelse	1,2	1,1
Stars	0,8	0,8
Tobakken	1,4	1,2
Train	0,9	1,1
Viften	2	1,6

Table 2. Bass ratios calculated for T30. As many low frequency problems at rock concerts are traditionally encountered in the 63 Hz domain this is included in the analysis.

4. DISCUSSION

Figure 1 shows no systematic difference between EDT in the audience area depending on whether the omni source or the house PA system is used.

From Table 1 and 2 it is seen that 2 out of the 3 lowest rated halls, Viften and Tobakken, have the highest bass ratios. The third low rated hall, Slagelse, has high T30 values at all frequencies (Figure 2). What all three halls have in common is a T30 value below 100 Hz well above 1.5 Sec. This suggests at least three possible criteria for halls for popular music (valid for empty halls):

1) the (modified) bass ratio should not exceed 1.2, i.e. the hall should be frequency balanced with respect to T30. As modern, powerful amplification systems are capable of high bass output a bass ratio below 1.0 would not be a disadvantage – but often this will be difficult to obtain in practice.
2) the frequency averaged T30 should be in the range 0.8 to 1.0 Sec. Figure 2: the T30 values in the seven halls investigated lie within a rather large interval from 0.6 to 1.7 Sec. at mid frequencies, and both extremes were found not to be ideal. However, as in halls for other purposes, the optimal reverberation time is likely to depend on the volume and in very large halls 1.0 Sec. may be difficult to achieve.
3) T30 must not exceed 1.5 Sec. below 100 Hz.

In Figure 3 an equivalent absorption area per (standing) listener (Beranek, L. L., *Acoustics*) has been used to calculate T30 in the halls when occupied. As the ratings in Table 1 relate to occupied halls these values are also of interest. Furthermore, both the absolute volume (Table 1) and the volume per listener (Figure 3) are seen to be much lower for the rock halls investigated than for most classical halls. Figure 4 shows the results of a low frequency (63-250Hz) D50 analysis. With only one exception the use of omni source on stage gives higher D50 on stage while D50 is higher in the audience area when using the house PA. The latter is not surprising and probably tells more about loudspeaker radiation patterns rather than about room acoustic differences between the stage and the audience area. Finally, in halls for rock music, the modified bass ratio – including the 63 Hz octave – is more appropriate than the traditional measure as it better reveals problems in the deep bass.

5. REFERENCES

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[4] Gade, A. C., *Note 4213-3: Architectural acoustics*. Ørsted DTU, DK- 2800 Lyngby, Denmark, 2003.