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Real case measurements of new variable acoustics technology

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ABSTRACT

The author has over the course of the past 2-3 years developed a new variable acoustics technology in the attempt to improve the acoustic effect and the aesthetics of variable acoustic devices, compared to earlier technologies. According to state-of-the-art science, the effect of typical variable acoustics devices for concert halls has in general been too small in terms of achieved variability of reverberation time and has affected bass frequencies too little while high frequencies too much. Moreover they have affected the interior design of a hall in an often unattractive fashion. The new technology consists of modules that in the open state let sound enter to be absorbed while in the closed stated reflect sound. Modules can be applied in both ceiling and on wall areas and cover large unbroken surfaces for instance an entire wall or ceiling. Surface finishes are for instance lacquered or wood. 55 modules were installed in an acoustics laboratory in late June/early July of 2019. The lab is 194 m^3 and modules were installed on parts of all walls and ceiling. Each panel can be open/closed separately via a tablet PC interface and there are also 11 presets for preferred configurations of open and closed modules.

Keywords: Variable acoustics, New technology

1. INTRODUCTION

A very large part of music concerts played every year any given place in the world are performed in a non-favorable acoustic setting. This is often not due to overall “bad” acoustics of a given hall, but to *un-suitable acoustics for the type of music performed* at a given time in the venue. As a matter of fact, for a given size venue, the reverberation time must be reduced by approx. 50% for the hall to function equally well for chamber music (for instance an acoustic flute/guitar duet performing classical pieces) and amplified pop/rock music (2). Hence variability of a hall’s acoustics is and has been a key-focus from the view of building-owners and hall management who are only too aware of potential imperfections of their hall from their natural dealing with the visiting musicians and audience.

Moreover, according to recent research in the field of suitable acoustics for pop and rock carried out by the author, this mentioned reduction of reverberation time (RT) has to be achieved at low frequencies (1, 3), most noticeably in the 125 Hz octave band (2, 3) while high frequency RT should be lowered less (2, 3). There are several reasons for this:

- Audience absorbs 4-6 time more high frequency (HF) than low frequency (LF)
- Air also absorbs more HF than LF, also the air in the concert hall
- The directivity of the PA speakers used for the pop/rock concert have a 3-5 times higher directivity at HF compared to LF ensuring a much higher direct-to-reverberant ratio at HF.

Further, a prominent value of HF RT is needed also at pop and rock concerts! The notion of RT regarding pop and rock concerts differs on a basic level from our understanding of RT for classical music, where RT is used to (amongst other) enhance the sound level of the music. This is indeed not the case at rock concerts where the sound engineer with his level-controls and EQ means (hopefully) sets the correct level. For amplified music RT is much more, if not uniquely, referred to for its impact in the time domain, not sound-level domain, and is hence thought of as a sound quality parameter and not a sound level. This is of course only true in larger halls (larger than some 1000-2000 m^3). It has been substantiated on two occasions (1, 3) that the optimum RT for amplified

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pop/rock concerts is NOT 'as low as possible'. This is, as mentioned especially true, regarding HF. This is due to the fact that:

- Dynamic playing on many instruments including voice is taking effect mostly at HF (4). The hall needs to be able to reflect that (by not having a low RT at HF). Otherwise the musician will find the hall dull and unresponsive – "like hitting a pillow (1)"
- Audience cheering (which is *not* amplified) should be very audible for musicians
- Audience cheering should be very audible for audience – a concert is a social gathering

Also for other musical settings, such as a brass band requiring an RT in *between* that of chamber music and of rock music, HF RT is a necessity since also here instrumentalists need to be able to sense their dynamics. This certainly also benefits the audience.

The author has developed a new ON/OFF sound absorption module technology that complies with the above-mentioned criteria over the course of the past 2-3 years. The technology is embedded in wall and ceiling areas (Figure 1).

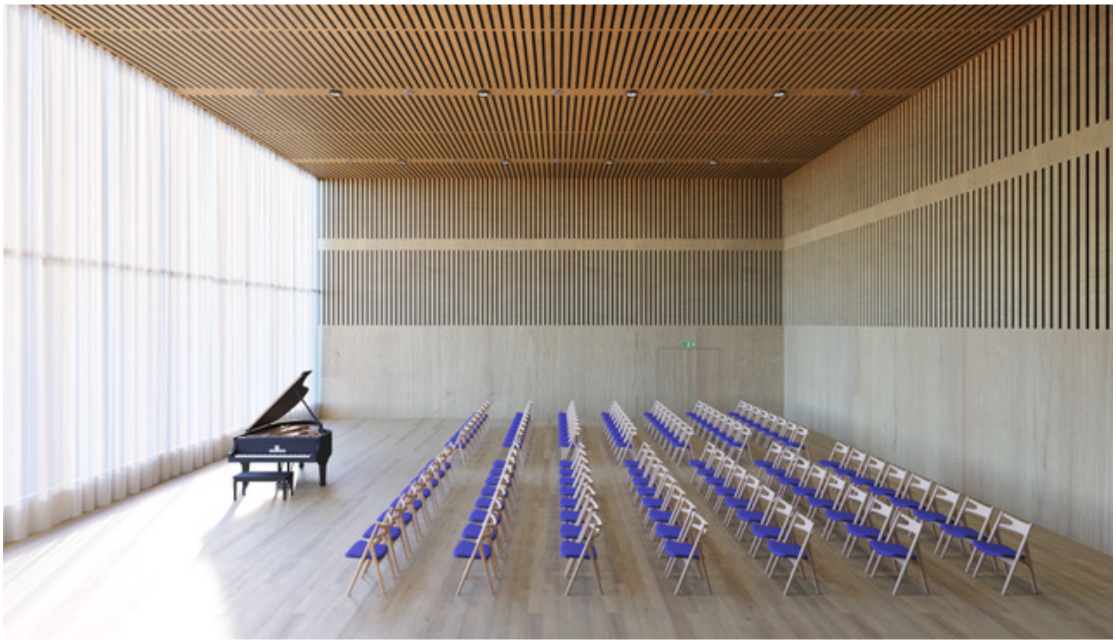

Figure 1 – The variable modules can be embedded into the interior architecture of the hall by mounting front panels of various materials, such as wood, flush onto the modules

The absorption curve for the module in the absorptive (open) and reflective (closed) states are shown in Figure 2.

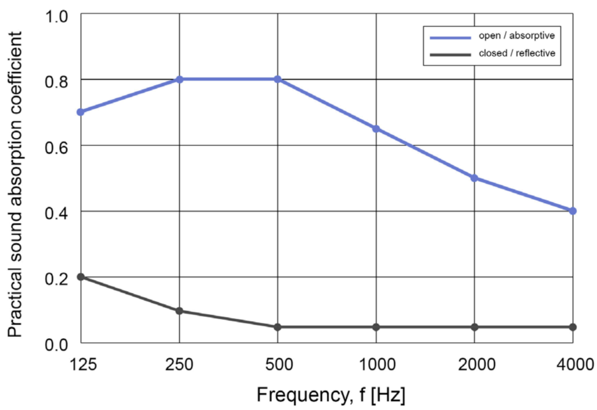

Figure 2 - The absorption curve of modules in their absorptive (open) and reflective (closed) state

2. Real case installation of the technology

2.1 The installation

The first installation of the technology was carried out late June 2019 in a 194m^3 acoustics lab measuring 8,7m x 6,2m x 3,6m. After installation of 55 modules with dimensions 240x60 cm (a total of 80 m^2) and a mounting depth of 0,4m the effective room-volume is 163m^3. The modules were mounted on a portion of all four walls and a portion of the ceiling area (Figure 3 and 4). Each panel can be opened/closed separately via a 12-inch tablet PC interface and there are also 11 presets for preferred configurations of open and closed modules (Figure 5).

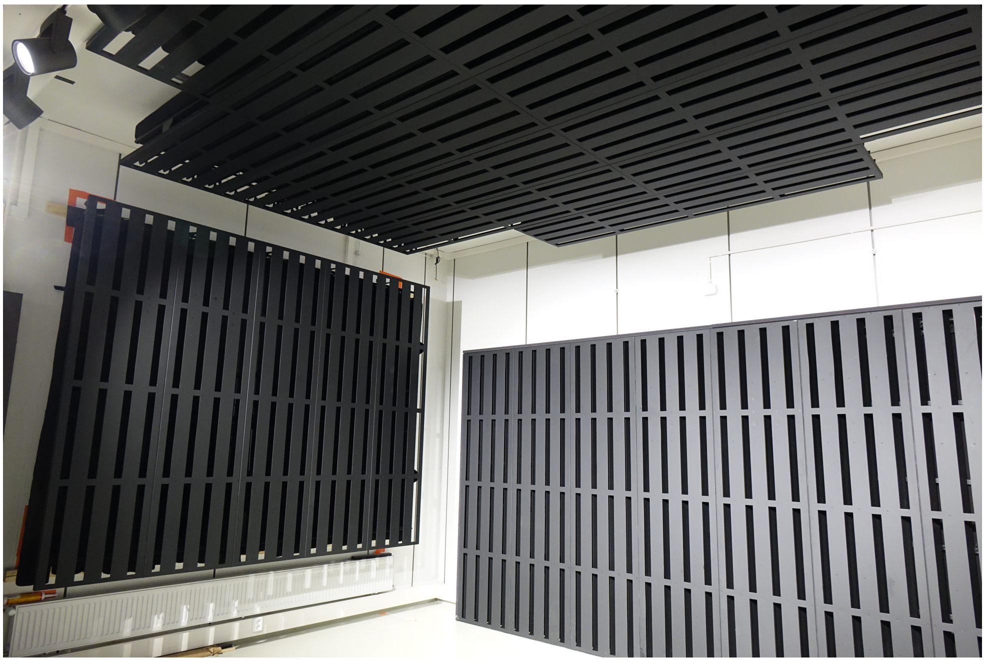

Figure 3 – photo of one end of the lab w. modules open (sidewalls not yet mounted)

Figure 4 – photo of closed, wall-mounted modules

Figure 5 - Each of the 55 panels can be opened/closed separately via a 12-inch tablet PC interface; there are also 11 presets for preferred configurations of open and closed modules

2.2 Measurements

Unfortunately the local carpenter did not finnish on time the mounting of side panels that hinder the sound from entering the absorptive material behind the modules from the side. Therefor no reliable measurements could be carried out. Some *in situ* measurements were made thereafter though in extreme hurry, however absolutely *not* reliable: a directional sound source, all measurements with microphone 20 cm from the floor, not enough measurements according to ISO 354, lots of other items in the room etc. Some trends can be seen from the measurements of which a typical example of both long and short RT is shown in Figures 6 and 7 (average of 3 measurements in just one position).

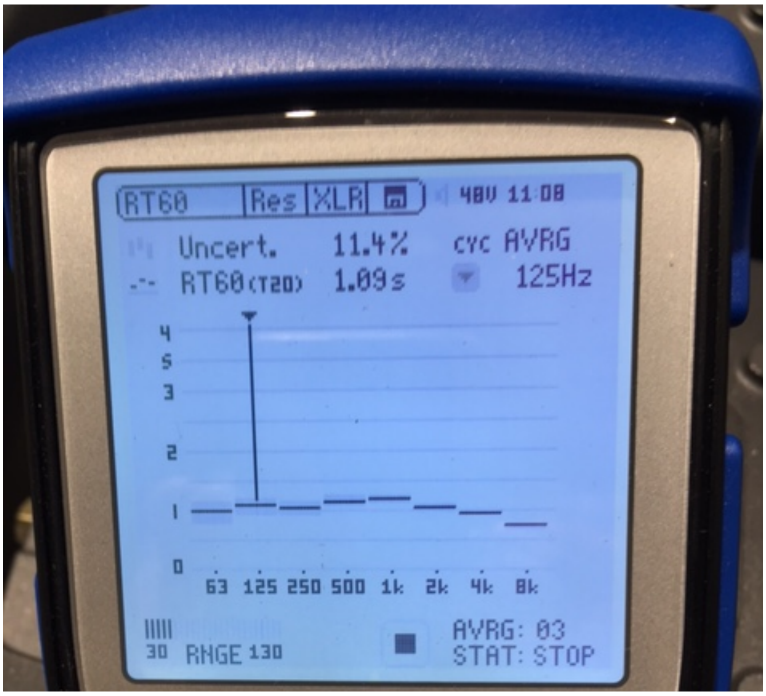

Figure 6 – a measurement of the long reverberation time in the room

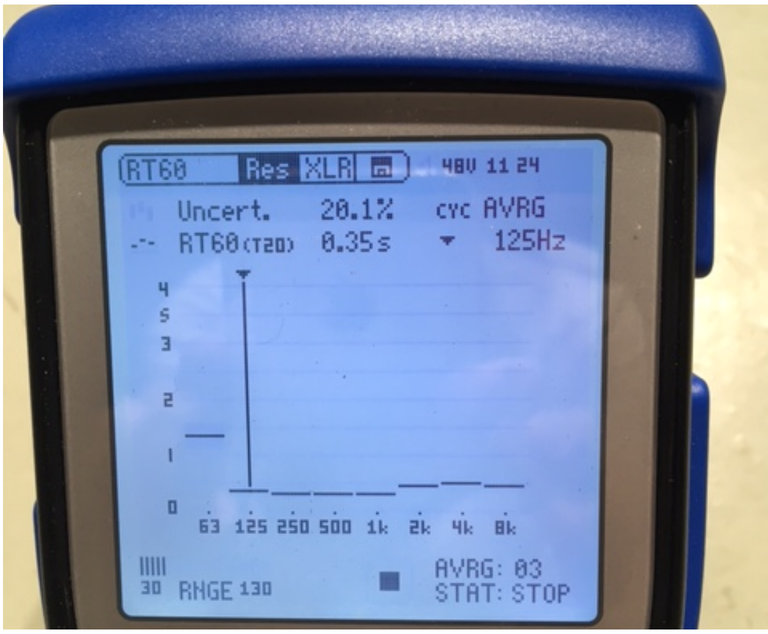

Figure 7 – a measurement of the short reverberation time in the room

It is seen from Figures 6 and 7, that

- RT is quite linear over the frequency bands 125-1k Hz, then rolling off at HF in the reflective state of modules (this resembles a good music venue for classical music)
- RT is quite linear in the frequency bands 125-1k Hz, then increasing a bit at HF in the absorptive state (this resembles a good music venue for amplified music)
- RT is lowered by approx. 65 % in the "important" bands 125-1k Hz, which interval contains the fundamental frequencies of most music instruments

3. OTHER IMPORTANT INFORMATION

3.1 Intellectual property

The new variable acoustics technology has been patented. Innovation Fund Denmark (Ministry of Higher Education and Science) is contributing financially to the development of the technology.

4. CONCLUSION

The certified measurements (Figure 2) are a reliable way for acoustic consultants to calculate how big areas needing to be covered by modules in order to undertake a given variability of RT. The *in situ* measurements unfortunately cannot be trusted, but render however a vague substantiation for the certified measurement.

ACKNOWLEDGEMENTS

The author would like to thank everyone involved in the development of the technology. You know who you are. It is not a small task to undertake, to envision, develop, mature, quality test manufacture, install, patent, market a new technology of any kind. In this case this has come with substantial sacrifices. The workload has been comparable to at least half of that of a Ph.D. degree. The invested capital is substantial. On the basis of the above, including the scientific explanation

why this technology meets the needs in performing arts centers to new standards, it is the hope of the author that also acoustic consultants will embrace it.

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