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THE MUSIC REHEARSAL ROOM – FOR WORK AND LEISURE

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ABSTRACT

This paper will discuss a number of issues related to the design of music rehearsal rooms for large acoustic ensembles such as symphony orchestras, wind bands and brass bands. First, the authors attempt to define the purpose(s) of the practice room and which acoustic qualities are desirable and how to optimize the choice between different qualities when compromises have to be faced (often caused by limitations in the room volume available). Besides, are these qualities different for amateurs and professionals? The paper also discusses whether the acoustic requirements of symphony orchestras, wind bands and brass bands are sufficiently equal to justify grouping these ensembles into a single category, as is done in the Norwegian standard NS8178. The discussion of these topics will be supported by data from the authors' own consultancy work.

Keywords: Rehearsal rooms, large acoustic ensembles, brass bands.

1. INTRODUCTION

In the ongoing work on establishing a new ISO standard for music rehearsal rooms, two fundamental questions are:

- Which acoustical and architectural parameters should be selected for defining requirements/recommendations for successful room design.
- How should different ensemble types be structured and categorized with regards to requiring similar room properties.

In the Norwegian standard NS 8178:2014 *Acoustic criteria for rooms and spaces for music rehearsal and performance*[1], rehearsal rooms are organized according to ensemble size and three categories named "acoustic, loud music", "acoustic, week music" and "amplified music".

This paper will focus on rehearsal rooms for symphony orchestras, wind bands and brass bands, which is termed "large ensemble rooms" for "acoustic, loud music" in NS8178. Aside from setting different recommended minimum room volumes for these three ensemble types, there is no differentiation on requirements for rehearsal rooms for symphony orchestras, wind bands and brass bands in NS8178. An important question is whether the acoustical requirements for rehearsal rooms for these three ensemble types is sufficiently equal to justify such a grouping.

Room volume and ceiling height are often limiting factors when designing rehearsal rooms for large ensembles. This impose compromises between different acoustical properties that one would like to optimize.

To support the analysis, the following questions will be discussed:

a) Which acoustic aspects are mandatory for large ensembles?

b) Which acoustical qualities of the concert hall are most important to try to transfer to the ensemble rehearsal room? (This might also be related to: which properties – when inadequate - are the musicians best able to compensate for?)

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c) Which properties would the performers prefer optimized, if he/she had to choose? Are there any differences between the needs of professionals and amateur musicians (kids and adults), i.e. to which degree are the findings in the literature on preferred listening conditions for professional symphonic orchestra musicians also valid for amateur musicians – who often play in other types of ensembles than symphony orchestras, such as wind or brass bands?

The discussion will be supported by data from the authors' own consultancy work. The main author also has background as an amateur trombone player, having played in several brass bands, wind bands and student symphony orchestras, ranging from intermediate amateur to semi-professional level. For several years he alternated between playing brass band, wind band and student symphony orchestra on a weekly/monthly basis. Together with discussions with fellow musicians and conductors, this has given valuable experience with regard to discussing the questions presented above.

2. THE HIERARCHY OF THE ACOUSTICAL PROPERTIES

It might be useful to introduce a hierarchical approach to the different acoustical properties one might want to optimize. If focusing on the overall sensory experience and the purpose of rehearsing, the individual musician's objectives might be listed, in descending order, as:

1. Not painful (Not too loud)
2. Communication, interacting with the others in the ensemble (hearing others and yourself). Being able to "work out" the music in an effective way.
3. Not being dissatisfied with how one's own performance is experienced
4. Wellbeing, pleasure. Emotional impact.

Objectives 1. to 4. might be viewed in the perspective of Maslow's hierarchy of needs; all the higher ranked objectives need to be fulfilled, at least partially, in order to be able to consider objectives down the list.

In Table 1, objectives 1. to 4. are associated with acoustical properties that might be used to define design targets for ensemble rehearsal rooms:

Table 1 – The individual musician's objectives related to acoustical properties of the room

	Objective	Acoustical properties
1.	Not painful (not too loud)	Loudness, strength (G), distance to other musicians (direct sound level)
2.	Communication, interacting with the others in the ensemble	Balance, clarity
3.	Not dissatisfied with one's own performance	Timbre/frequency balance, support
4.	Wellbeing, pleasure. Emotional impact.	Timbre/frequency balance, fullness, reverberation

An important question is whether the order of importance for the acoustical properties explained by the order of the properties 1. to 4., or does one have to take into account *"which properties – when inadequate - are the musicians best able to compensate for?"*

3. DO THE NEEDS OF AMATEUR MUSICIANS COINCIDE WITH THE NEEDS OF PROFESSIONALS?

Most of the research on stage acoustics and musicians' preferences with regard to rehearsal conditions has been based on professional symphony orchestras. In order to develop suitable acoustic criteria for ensemble rehearsal rooms aimed at amateur ensembles, which constitute the majority of both new and existing rehearsal rooms, it is of relevance to discuss whether the research on professional orchestra musicians can readily be applied to amateur ensembles.

One approach is to discuss this question based on objectives 1. to 4. listed in chapter 2.

3.1 Not painful (Not too loud)

Perceptually, there is no reason that there should be any difference between professionals' and amateurs' tolerance for high sound levels during rehearsals, as long as neither have any hearing damage or hyperacusis. Due to the significant difference in exposure time during a typical week, compared to amateurs, it is still anticipated that professional musicians will be more concerned about too high sound levels during rehearsals. It is also likely that this higher exposure time, especially when taking into account individual practice in-between orchestra rehearsals and concerts, will imply that it is more important to control the sound levels in the rehearsal rooms for professional ensembles. Professional musicians are also protected by work environmental legislations, which also include sound exposure limits.

On the other hand, it is also important to protect the hearing of amateur musicians, especially kids. Excessive levels also reduce the ability to detect nuances in the music and might also cause a temporary threshold shift. Both effects will reduce the critical listening ability during rehearsals. The authors would suggest that avoiding too high sound exposure levels should be a primary focus when designing (and setting up the ensemble in) rehearsal rooms for both amateur and professional ensembles, but slightly lower room volumes, and hence higher G, might be acceptable for amateur ensembles.

3.2 Communication, interacting with the others in the ensemble

Perhaps this aspect is less important for lower level amateurs, if you ask them? On the other hand; lower level amateurs tend to have a less developed ability to listen to others, both regarding active "cocktail party listening" and sufficient capacity/overview to focus on more than their own playing.

A well-known challenge for amateur ensemble conductors is to quickly get to the stage where the individual musicians start listening and adapting to the rest of the ensemble, when starting to work on a new piece. For many amateur musicians this is related to getting to know the music well enough to be able to "raise your focus". The ability to subtly adapt to other musicians also during early rehearsal stages is often considered to be one of the major differences between skilled amateurs and professional musicians. Therefore, it is likely that a room acoustic design that facilitates critical listening and increases the focus on the performance and musical impulses from other musicians within the ensemble would aid in reaching the stage of "adapting to others" more quickly. Still, it is important that the balance between hearing yourself, your own instrument group, and the rest of the ensemble is adequate.

3.3 Not dissatisfied with one's own performance

When asking amateur players to judge the performance of the band or orchestra after an important performance, their answers seem to be strongly biased by the impression of their own performance, i.e. if they are dissatisfied with their own playing, it can be challenging to appreciate or even register an otherwise good performance by the ensemble as a whole. This effect is typically more evident during concerts than during rehearsals, but it still affects the ability to appreciate the rehearsals and feel that using your spare-time on a three-hour rehearsal is worth-wile.

The impression of your own playing is of course strongly correlated to the amount of "errors", but the feedback from the hall, and the impression of how your own playing blends in with the rest of the ensemble is also an important component with regards to being satisfied with your own playing and feeling secure enough to perform well even when nervous. The latter is a well-known challenge when amateur brass or wind bands move from a (too) small rehearsal room to the stage in a large symphonic hall for a concert or contest. It is not uncommon to hear comments that the players feel "alone" or "naked" in this situation, and that this enhances nervosity, which might in-turn trigger errors and insecurity. It is also important to experience a sufficient degree of "fullness" when listening to the room response of one's own instrument. The experienced degree of fulness can be related to the frequency response of the room, in terms of the balance between EDT at different frequency bands and the avoidance of flutter echoes or similar detrimental effects. It is also worth noting that amateurs often have a lower degree of self-confidence with regard to their own production. The performance also tends to vary more from day to day, probably because most amateurs don't practice as regularly and systematically as professionals. These effects leave amateurs more sensitive to an unbalanced room response, while a professional musician is typically better on "doing what he or she knows is right" even if the feedback from the room is unpleasant or too weak.

One way to make the players better prepared for performing in a large symphonic hall, is to try to make the experience in the rehearsal room more similar to that on stage. In this context, it is likely that it is more important to mimic the properties of the early reflections and the inter-ensemble balance on-stage, than the properties for the reverberant field.

Seen in light of the discussion in section 3.2, the conclusion might be that in ensemble rehearsal rooms for amateur ensembles one should aim for a balanced room response that facilitates critical listening without being overly revealing. At what point this balance is found is likely to be dependent on both individual preference and the quality and type of ensemble, which indicate that a certain degree of variable acoustics would be advisable.

3.4 Wellbeing, pleasure. Emotional impact.

Pleasure is, after all, the purpose of playing (or listening to) music for most people. But perhaps is it even more important for amateurs than professionals, because a strong motivation for playing in an ensemble is the social experience and obtaining a positive sensory impact.

Based on the discussion in the preceding sections, it is still a question where to strike a balance between obtaining wellbeing or euphony "there and then", and the motivation and satisfaction gained by experiencing to improve. Maybe the answer is that the amateur ensemble rehearsal room should be "comfortable enough" so people don't quit but sufficiently transparent for the players to hear their faults so that the ensemble and the individual players improve their skills. This requirement is also strongly related to the proposed "balanced room response" in section 3.3, but it is likely that the wish for transparency correlates strongly with the level of the ensemble and the individual musicians.

To sum-up, the order of the objectives 1.-4. listed in chapter 2 is probably not altered for amateurs compared to professionals, but the tendency seems to be that importance of the different objectives is more equal for amateur musicians.

A conclusion might be that there should be a somewhat higher focus on controlling sound exposure levels, obtaining clarity and facilitating analytical listening when designing rehearsal rooms for professionals than for amateurs. A slightly higher RT might be favorable for amateurs if the level is controlled. On the other hand, amateur ensembles more than often practice in rooms that have too low volume. To counteract excess G values, and to reduce the reflection density, i.e. provide sufficient clarity, a relatively low RT would also be necessary in such cases. Also bear in mind that while amateur symphony orchestras often have fewer musicians than a full-size professional orchestra, professional wind bands are typically much smaller than skilled amateur wind bands. The number of musicians in the ensembles that the rehearsal room is designed for should be taken into account when the decision on necessary room volume is made. One should also bear in mind that for amateur wind bands, the size of the ensemble tends to increase as the level of the ensemble improves, due to a desire to perform advanced original works or transcribed symphonic music using full instrumentation.

It should also be noted that there is a gradual transition from experienced amateurs to professionals, also regarding needs. Based on the authors' experience, skilled amateurs (i.e. Elite and 1. division wind and brass bands) are more comparable to professionals than amateurs, both regarding the sound level generated and acoustic preferences.

4. SUGGESTED ACOUSTICAL PARAMETERS FOR THE NEW ISO STANDARD

Based on the discussion in chapter 3, it seems clear that reverberation time is not a sufficient design parameter when defining design criteria for ensemble rehearsal rooms. In addition to the control of sound levels (G), other parameters which characterize the properties of the early reflected field in the room should be emphasized. Central properties are:

- Balance between hearing one-self, own instrument group and the rest of the ensemble
- Obtaining sufficient clarity (but not too analytical)
- Reducing masking – especially when playing is blurred (poor rhythmic precision and poor balance)
- Preserving timbre
- Obtaining sufficient "fullness"

An obvious challenge when developing the new ISO-standard, is to define acoustical parameters that also can be turned into physical design criteria. It is of critical importance that the new standard is sufficiently "useable" both for the design of new and the improvement of existing rehearsal spaces.

Within the research on stage acoustics for symphonic halls, several researchers (2,3,4,5) have pointed out that sparse, distinct early reflections separated in time and direction (and limited reverberant energy) seem to be favorable with regard to both the room response not masking ones' own sound and louder instruments not masking quieter instruments. How should these parameters be balanced in rehearsal rooms that typically have significantly smaller volume than the typical concert hall?

In the case of too small rehearsal rooms, a possible approach is to start by looking at the distance to reflecting surfaces from different parts of the ensemble for different room dimensions, volumes and ensemble setups, to decide whether reflections from walls and ceiling need to be (partly) absorbed or oriented away from the ensemble to obtain a sufficient *sparseness* and distribution with regards to level, time and direction. Also, the degree of diffusion should be controlled. Computer simulations, scale model or mock-up studies might be used to study these relations, ideally coupled with studies of performer preference. Based on findings from these studies, recommended minimum room volume and minimum ceiling heights, and corresponding optimum reverberation times might be derived. It should be noted that with such an approach, the reverberation time is for a given room volume no longer a design target in itself, but merely a result of the necessary degree of absorption and scattering from the different wall and ceiling surfaces.

Besides refining recommendations on room volume, ceiling height and reverberation time, one approach to obtaining a "useable" standard might be to develop suggestions for the distribution of semi-absorbing, reflecting and diffusing surfaces based on results from the studies suggested above. Another approach might be to describe recommended properties of the early reflected field as reference for computer simulations or detailed measurements of the room response using IRIS® or similar measurement systems.

In NS8178, requirements for volume per person (V/N) are presented to ensure sufficient absorption, i.e. to control G. The authors would suggest to replace this parameter with absorption area per. person (A/N) in the upcoming ISO standard, as introduced in (6). This parameter is more directly related to what we want to control; level and the balance between hearing oneself and others. The suggested parameter A/N also emphasises the need to reduce the reverberation time below recommended values in NS8178 when the room volume is too small compared to the ensemble size. It is worth noting that the recommended reverberation times for the ensemble rooms for acoustic louds music, which typically range from 1000 to 6000 m³, varies relatively little as a function of volume. This implies that G depends strongly on room volume, which is illustrated in Figure 1. From Figure 1 it is also worth noting that the average absorption coefficient will be larger for a small than for a large ensemble rehearsal room, if following the recommended reverberation times in NS8178. Because the smaller room will have a shorter average distance from sources to room boundaries, which imply stronger and more dense early reflections, one would expect that a somewhat larger average absorption coefficient would instead be needed to avoid a too dense and strong reflected sound field in the smaller room. In (6) a minimum absorption area of 8 m²/person is recommended for professional orchestras. This value results in somewhat larger minimum volumes than the guidelines found in NS8178, and might be unrealistically large for amateur wind bands and symphony orchestras. Based on the discussion in section 3.1, a recommended minimum absorption area of 6 m²/person for amateur wind bands and symphony orchestras might be sufficient.

4.1 Differences between different ensemble types

As mentioned in the introduction, symphony orchestras, brass bands and wind bands are treated as one group in NS8178. To discuss whether the acoustical requirements for rehearsal rooms for these three ensemble types is sufficiently equal to justify such a grouping, it might be useful to characterize the differences between these ensemble types.

A full-size wind band resemble the symphony orchestra with regard to instrumentation, number of musicians and primary repertoire. The authors do not see that it would be advisable to separate the requirements for rehearsal rooms for these to ensemble types. Brass bands, on the other hand, differ from symphony orchestras in several ways that might justify presenting separate acoustic requirements for this ensemble type:

- The average source power is significantly higher, due to the instrumentation. If calculating the total source power of the ensemble, using the method presented NS8178 Appendix A, one finds that a standard 28-person brass band is equally loud as a full-size symphony orchestra. This implies that one should not allow a noticeably higher G for brass bands than for a large symphony orchestra, even though the brass band will have sufficient (floor) space in a significantly smaller rehearsal room. This requirement corresponds to increasing the recommended absorption area per person, compared to recommendations for symphony orchestras, as presented in (6).

- The variation in sound power level between different instruments groups is significantly smaller. This affects both the level and optimum distribution of reflections. The subject of providing good listening conditions between the different string sections, without being masked by the brass players, which is addressed in (4), is not relevant for brass bands. This implies that the recommendation in (4) to focus on vertical reflectors on stage that support listening across the string group is not transferrable to brass bands. If one looks at the directional properties of the different instrument sections in the brass band, with mostly highly directional instruments, many of them pointing upwards (middle section plus tubas), it becomes evident that there should be a good balance between early reflections from the side walls and the ceiling. The common recommendation to introduce some absorption on the rear wall to control the level from the percussion section is, on the other hand, also valid for brass bands.
- Brass bands have a more "dense" sound than an orchestra, especially when taking into account the number of musicians. This is related to both instrumentation, ensemble size and typical orchestration style. A lot of the original brass band music written for experienced ensembles tend to require very good technical skills, and is often very complex in terms of using multiple, complex musical layers presented simultaneously. These properties all contribute to more severe masking, which emphasizes the need to provide a sufficiently sparse reflected sound field. This results in a requirement for a lower reverberation time for brass bands than for symphony orchestras, given equal room volume. For rooms of smaller volume, the reverberation time would need to be reduced even further to ensure sufficient control of G and to counteract the effect of bringing the walls and ceiling closer to the ensemble. This is also in line with the discussion related to average source power and the findings presented in (7).

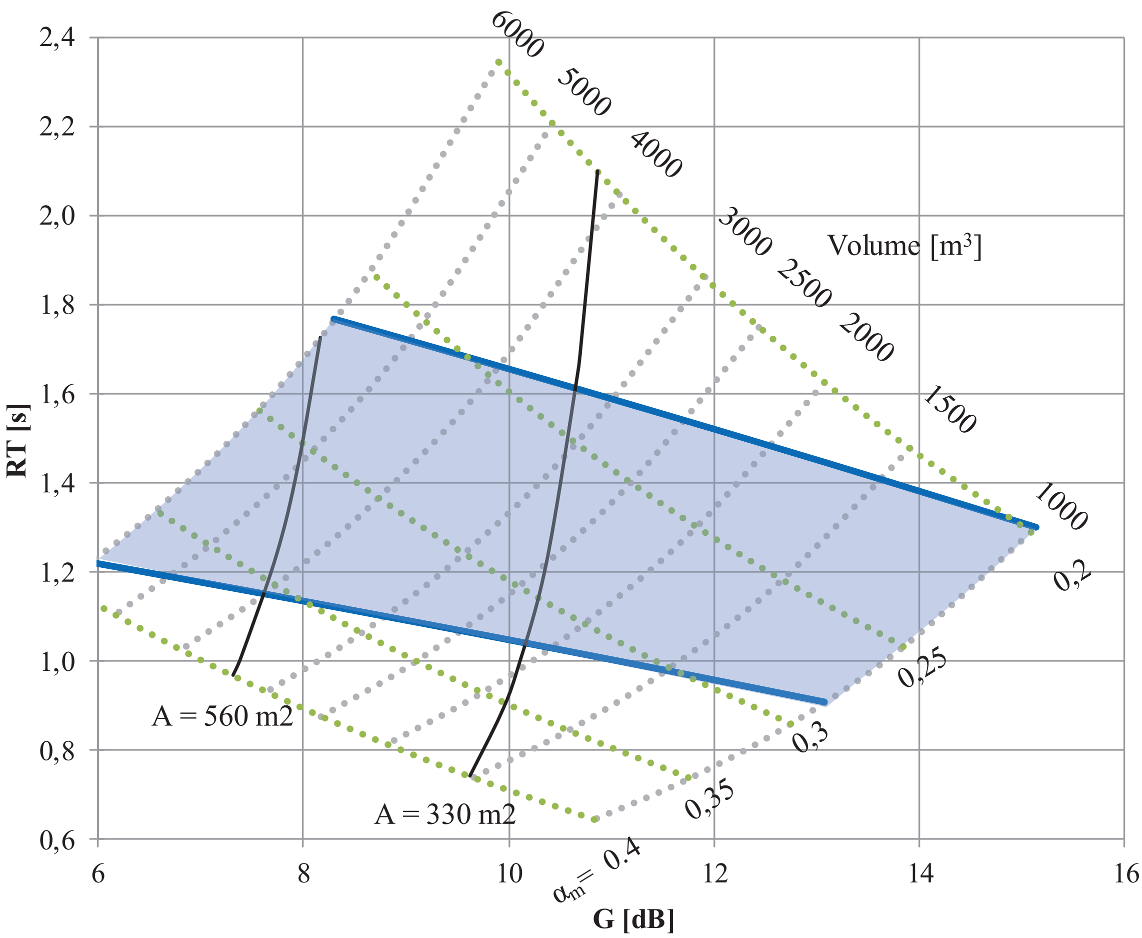

Figure 1 – Recommended reverberation times in NS8178 for ensemble rooms for loud acoustic music, as a function of room volume. Blue lines correspond to the minimum and maximum values given in NS8178, extrapolated to 6000 m³. Green dotted lines indicate G-RT contours of equal average absorption coefficient α_m, based on a typical shoe box-shaped room, and grey dotted lines indicate G-RT contours of equal volume. G-RT contours corresponding to the suggested minimum

absorption area for a 70-person professional symphony orchestra (560 m^2) and for a standard brass band / 55-person amateur wind band (330 m^2) is also shown (black solid lines).

Summed up, the authors would suggest to establish separate requirements for brass bands in the new ISO-standard, focusing on somewhat higher clarity and lower reverberation time than for symphony orchestras and wind bands, and also pointing out the importance of a good balance between ceiling and side wall reflections. The minimum absorption area per person should also be increased for brass bands, for example to approximately 10-12 m^2. The suggested minimum absorption areas are illustrated in Figure 1 for a few typical ensemble setups. It might be noted that NS8178 Table 2 (1) implies a minimum volume of 30 m^3/person for wind bands and orchestras, but 50 m^3/person for brass bands. This differentiation is in line with the above suggestions, but the minimum volume per person would need to be increased to correspond to the proposed minimum absorption area per person – without getting too low reverberation times.

The above discussion also indicates that rehearsal rooms for orchestras and large wind bands should work well also for brass bands, by introducing some variable absorption, provided that there are sufficient ceiling response (for the "upwards pointing" brass instruments).

5. CONCLUSIONS

When designing rehearsal rooms for large acoustic ensembles such as symphony orchestras, wind bands and brass bands, it is often necessary to balance the different acoustical properties that one would like to optimize, due to limited room volume. Based on an analysis of the order of importance of the different acoustical properties, the authors would suggest the following prioritization:

1. Control the sound level; ensure that G is not too large, and that the room has sufficient floor space to accommodate an ensemble setup that leaves some space between individual musicians and to reflecting walls.
2. Obtain a good balance between hearing one-self, own instrument group and the rest of the ensemble, and sufficient clarity; ensure that early reflections are sufficiently separated in time and space, that the strength of the reflections are controlled by partial absorption, particularly for smaller rooms, and that the reflecting surfaces are distributed in a way that supports mutual hearing between instrument groups (optimum distribution depends on ensemble type)
3. Preserve the timbre of the instruments, ensure sufficient "fullness"; ensure a balanced frequency response of the hall, also for individual (early) reflections. Allow for as much reverberation as possible without sacrificing properties 1. or 2.

The prioritization listed above might be used as input in the development of the new ISO standard, to aid in defining objective parameters that can be used as design criteria.

The authors would also suggest to replace the requirements for minimum volume per person (V/N) used in NS8178 with absorption area per. person (A/N). The proposed value in (6) of minimum 8 m^2/person for professional orchestra might be reduced to approximately 6 m^2/person for amateur wind bands and symphony orchestras.

Based on a comparison of ensemble properties and acoustic requirements for brass bands, wind bands and symphony orchestras, the authors would also suggest to define separate requirements for brass band rehearsal rooms. The requirements for minimum absorption area per person should be increased to approximately 10-12 m^2/person for brass bands. In addition, the room should have somewhat reduced reverberation time and increased clarity, compared to ensemble rehearsal rooms for symphony orchestras and wind bands.

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