



## Acoustics in rooms for music rehearsal and performance – the Norwegian experience

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Each week local music groups in Norway use more than 10.000 rooms for rehearsal and concert, many of the rooms are in schools. The size of the rooms vary from under 100 m<sup>3</sup> to over 10.000 m<sup>3</sup>. The users cover a broad variety of music ensembles, mostly wind bands, choirs and other amateur ensembles. Since 2009 the Norwegian Council for Music Organizations («Norsk musikkråd») has completed more than 700 room acoustical measurement reports on rooms used for rehearsal and concert. The measurements include reverberation time, the strength parameter G and background noise. All the reports are made available online in a Google Map. The analysis shows that 85% of the rooms do not comply with the Norwegian Standard NS 8178:2014 and are evaluated more or less unsuitable for the purpose for acoustical reasons. The important criteria are volume, room form and dimensions, reverberation, acoustic treatment of surfaces, and background noise. In particular, the importance of volume is clearly documented. Analysis of room strength indicates that this also is an essential factor for this type of rooms. The systematic collection of acoustic reports gives important background data for recommendations on how to build or refurbish rooms for music in schools and cultural buildings .

This work, combined with 6 years of experience from using the Norwegian Standard NS 8178 is also used in the ongoing process in the ISO Work group ISO TC 43/SC 2 WG 33 developing a new ISO standard “Acoustic criteria for rooms and spaces for music rehearsal”.

The Norwegian experience also clearly shows the importance of close relationship between the owners (municipalities, government etc), the users (choirs, bands, music schools, musicians) and the acousticians – “the golden triangle”.

### 1 Introduction

The council for Music Organizations in Norway is an association of more or less all nationwide music organizations in Norway, covering choirs, orchestras, jazz groups, wind bands, folk music, etc. and we also cover concert producing organizations and the Union of Musicians. One of our main focus points is to work with improving the rehearsal and concert rooms used throughout Norway. In our everyday work, we hear from our members that they are not satisfied with the rehearsal and performance conditions, the rooms seem to be not properly suited for music use. In fact, this is one of the problems we encounter most. The problems occur both in rehearsal rooms and in concert rooms, and the problems have been addressed for decades.

From a musician’s point of view, the rehearsal room is the most important room. That’s where we spend most of our time. For a choir or an orchestra, the rehearsal room is the «home ground», where we learn to play or sing together with the other musicians. We adapt our musical skills to the acoustical situation in the rehearsal room, and if this is not ok, we learn to play in an unbalanced way, or to develop poor sound quality and timbre. The concerts are where we «show off». That’s when we want to present ourselves at best, for the audience and the local community. In many ways, our concerts are also our pay-back to the society. That’s a part of our way of making the local community a better place to live. The

concerts are also a recruitment arena for our music ensembles. If a music group sounds well, people will want to join and to be a member of that group.

Our investigation shows that in Norway alone, more than 10.000 rooms are used for music purposes every week. Most of these rooms are not mainly designed for music use, but they are used because they are available and there are no other options.

## **2 The Norwegian approach – what have we done**

The council for Music Organizations in Norway started to cooperate with Norwegian acousticians at the end of the 1980s. And we have had excellent cooperation with several acousticians since then. We feel that long-term, systematic cooperation between acousticians and music organizations has been successful and – after many years of work – has improved both the rehearsal and concert conditions for many musicians – for amateurs, music teachers and professional musicians.

Our cooperation started with the Norwegian acoustician Svein Strøm, who made acoustic measurements and reports for us in Akershus County in 1986-89, leading to our first publication “Bedre akustikk. Gode råd om forbedring av akustikk i lokaler til musikkformål” (“Improved acoustics. Practical advices for improving the acoustics in rooms for music purposes”) in 1989 [1]. This publication was followed by more measurements, and a second publication in 1991 “Bedre akustikk II. Sang og Musikk ute” (“Improved acoustics II. Singing and playing outdoors”) [2].

The major milestone in our work till now has been the publication of the Norwegian standard NS 8178:2014 “Acoustic criteria for rooms and spaces for music rehearsal and performance” [3]. The work started in 2011 and since then, the awareness of the acoustics and the impact for our playing and singing in Norway has become much stronger. We feel that this is one of the major effects of the NS 8178, that conductors, musicians, music schools and young and old musicians playing or singing in choirs, wind bands, orchestras, pop and rock bands now see even more than before the importance of suited rehearsal and concert rooms. In addition to be helpful in planning new rooms for music and the refurbishment of existing rooms, the Standard can also be used to assess the suitability of existing rooms for different musical purposes.

Together with Standards Norway we have also initiated the development of an international ISO standard for music rehearsal rooms.

Each year, we publish our recommendations for rooms and spaces for music use, a supplement and guidelines to better understanding the NS 8178 [4]. The target group is primarily the music organizations, conductors, politicians, municipalities and the general public interested in rooms for music use. The 2021 version also includes recommendations for music teaching rooms in schools and music schools. We also publish a separate website <http://www.musikklokaler.no> [5] focusing on rooms for music activities, acoustics, guidelines, news etc.

The council for Music Organizations in Norway launched in 2009 a systematic program of acoustic measurements in rooms used for music playing and/or singing. Till now we have analysed more than 700 rooms and issued acoustic reports from each room. Most of the reports are published online in an interactive map at <https://database.musikklokaler.no/musikk/map>, [6]. What we learn from these reports is one of the main foundations we use in our work. To obtain even more knowledge we have initiated a survey including other cultural activities (theatre, dance etc) in cooperation with the Norwegian “Kulturalliansen” (“Cultural Alliance”) [5]. This survey now includes more than 500 rooms and is rapidly growing. This survey is also supported by the Norwegian Culture Ministry and is also used as reference in “The Power of Culture – Meld. St. 8 (2018-2019) Report to the Storting (white paper)” [ 7] and “Meld. St. 10 (2018-2019) Report to the Storting (white paper): “Voluntary sector” [ 8].

## **3 Many rooms are in use for music purposes**

Our investigation shows that in Norway alone, more than 10.000 rooms are used for music purposes every week. This is based on our member lists, our knowledge from music practise in Norway and data from Statistics Norway [9].

This figure corresponds also well with a survey in an average municipality in Norway, Eidsvoll [10]. The municipality has 22.000 habitants, and we found 44 rooms in use for music activities.

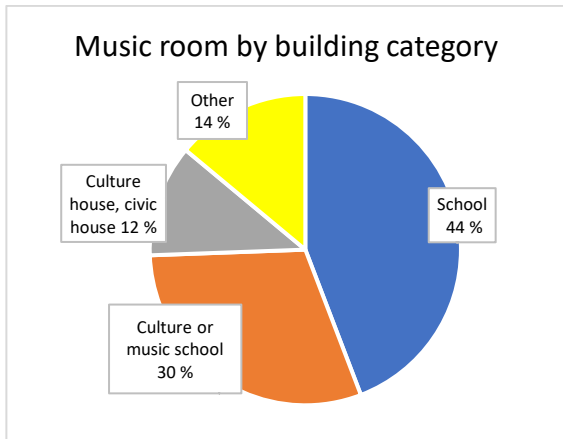


Figure 1: In what building category are the music rooms located

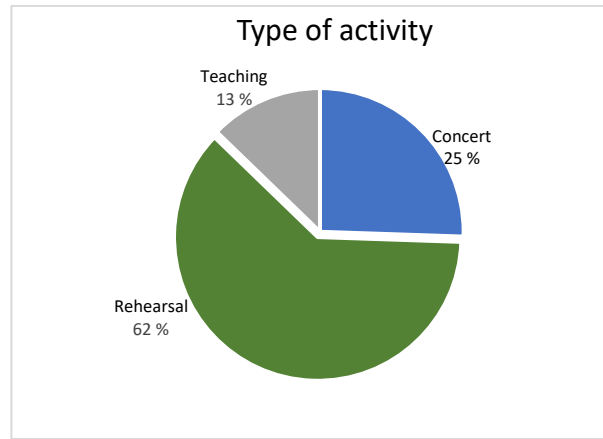


Figure 2: Type of activity

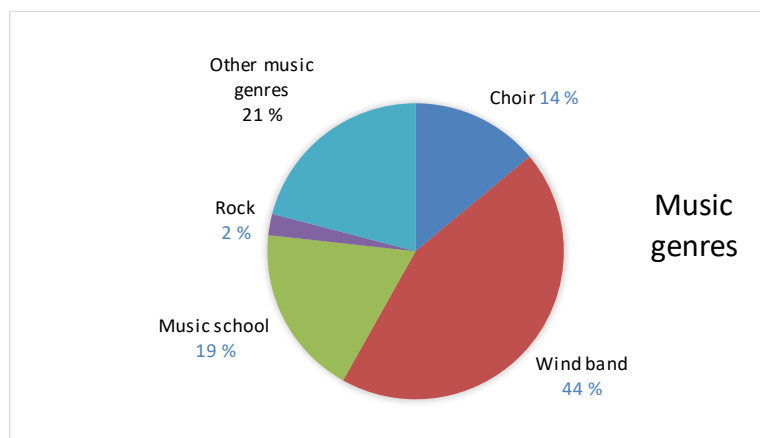


Figure 3: Music genres

International surveys also show that many rooms are in music use. Figures from European Choral Association ([https://europeanchoralassociation.org/wp-content/uploads/2019/01/singingeurope\\_report.pdf](https://europeanchoralassociation.org/wp-content/uploads/2019/01/singingeurope_report.pdf)) [11] show that there are 37 million people singing in choirs in Europe. 4,5% of the European population takes part in collective singing, in more than 1 million vocal ensembles. Knowing that most rooms are used by one ensemble, this indicates that there are close to 1 million choir rehearsal rooms in Europe.

This survey shows that the most popular places for vocal ensembles rehearsals are educational institutions (schools etc) (28 %), religious buildings (20 %) and community centres (19%).

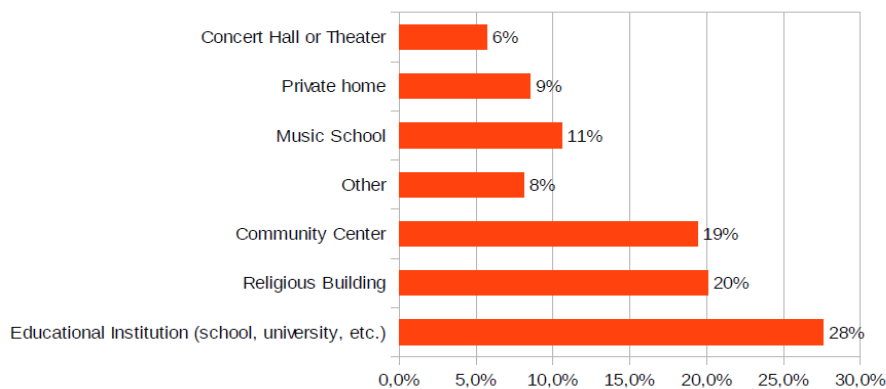


Figure 4: Rehearsal places for choirs and vocal ensembles in Europe

Based on the 4123 answers from the questionnaire, the average size is 36 singers per ensemble. The standard deviation of 28 indicates that this average value covers very diverse reality, as the graph below shows. The red line is a moving average of the last 5 entries to smooth down the over representation of the round values (the peaks at 30, 40, 50, 60 singers) that appeared when people made rounded estimations of their ensemble's number of singers instead of precisely counting them

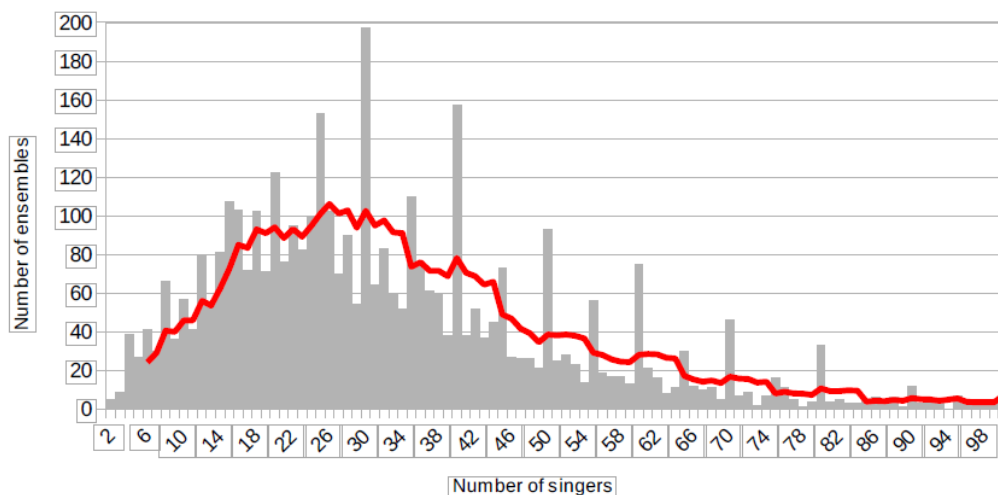


Figure 5: Repartition of singers in choirs and vocal ensembles in Europe (1-100 singers).

German statistics from the “German Bundesmusikverband Chor & Orchester e.V” (<http://bundesmusikverband.de/zahlen/>) and the German Music Council (“Deutscher Musikrat”) [12] show that more than 14 million people in Germany sing or play in music ensembles. One of their conclusions is that “We can therefore conclude [...] that about 14 million people in Germany makes music in their leisure time. This is about 17% of the whole German population”. The same statistics show that there are more than 4,8 million choir singers in Germany.”

#### 4 Experience after 6 years with NS 8178 Acoustic criteria for rooms and spaces for music rehearsal and performance – and measuring more than 700 rooms for music use

First of all, the reports conclude that about 85% of the rooms are not suited for the music use they in fact are being used for. Many of the rooms are so unsuitable that rehearsals in these rooms in fact destroy the music development of the music group.

The Council for Music Organizations in Norway and all our regional and local units have been working to promote the Standard since it was established in 2014. We have had an extra focus in working with schools, as school buildings are the buildings most used in Norway for music rehearsal, and also for small local concerts. Three years after the Standard was established, we now see that more and more local governments use the Standard as a base when working with new buildings. And we also see that when using the Standard, the rooms planned for music use are better suited than when the Standard is not used. This tells us that the Standard is a good tool as useful in the real world.

We see that one of the most important effects of the NS 8178 may be that an official standard forces the owner to decide the primary use for each room. Discussing acoustic priorities, better definition of primary and secondary use, and better dialogue between commissioner, users and acousticians in new buildings are other very important outcomes of the NS 8178. These discussions are now not something extra, to be taken when the project has come a long way but is more and more normal at the starting point for new projects. We feel that this is especially important when building new schools, since the schools are by far the most common rehearsal room for local music groups. Schools are also often used as concert rooms for local ensembles therefore we think it's very important that there has been a shift in school planning in many municipalities, much due to the NS 8178.

Our main experience is quite clear – the main problems are room volume and room dimensions. There are also often problems with the reverberation time, not only  $T_m$ , but also to have an even frequency pattern and to have the same acoustic condition in all parts of the room. We also experience some problems with acoustic adaptation and echo effects – and last, but not least we often encounter too much background noise.

## 4.1 Room volume

The main problem in everyday music life is that the rehearsal room and the rooms we use for concerts are too small.

For choirs, a survey by Norsk sangerforum tells us that 75% of the choirs have rehearsal rooms that are too small, more than 50% of the rehearsal rooms are less than 300 m<sup>3</sup>, which is half the size for a suitable choir rehearsal room. Many choirs never get the chance to use a suitable rehearsal room and don't realize or know how important this is and how important a suitable room is for the musical development of the choirs. As one of our respondents answer "The acoustics are quite ok" – when their rehearsal room is an ordinary classroom of 6 x 4 x 2,5 m and the choir has 43 singers. This is 1,4 m<sup>3</sup> pr singer – in NS 8178 the minimum is 20 m<sup>3</sup> pr singer and a minimum volume of 700 m<sup>3</sup>. Our experience is that the volumes in NS 8178 for quiet acoustic music is ok. Unfortunately, few quiet acoustic music groups have big enough rooms.

We also often see too small rooms in music schools. NS 8178 specifies music teaching to be held in the room category of small ensemble room. We often see that the teaching rooms are small rehearsal cells, rooms that slows down the music development of the student and makes the working conditions for the teacher very difficult. Too small rooms, especially for loud music instruments, may also cause hearing damages for the teacher who has to work hours after hours in poor acoustic conditions with too loud sound.

A third major problem is the wind band rehearsal rooms. In Norway we have many wind bands, school bands and amateur bands. The NS 8178 gives a minimum criteria of 1000 m<sup>3</sup> for concert bands and minimum 1500 m<sup>3</sup> for brass bands, and minimum 30 m<sup>3</sup> pr musician. Many wind bands with 25-40 musicians use rooms of about 1000 m<sup>3</sup> as their rehearsal room, our experience is that this is too small. We have recommended an increase of 50%, at least for ensembles of adult musicians, and this seems to correspond much better to the needs of the wind bands.

## 4.2 Room dimensions

The NS 8178 does not say much about room dimensions and geometry other than recommendations of angled walls in smaller rooms and avoiding sound focusing and echoes in larger rooms – and a note regarding loud acoustic music that the ratio between length and width of the room should not exceed 1:1,6. In addition there are figures given for room height for each type of room.

Our experience is that there often are problems with room dimensions. There are some problems with rooms having too small room height, most common in choir rehearsal rooms (large ensemble rooms for quiet music) but also in rooms for loud acoustic music (all room categories).

We also often see rehearsal rooms that are too oblong, with ratio length:width of more than 1:2, up to 1:3 and more. When talking to musicians using these rooms, they confirm that they are very difficult to play or sing in. This is a more common problem than one might think, the problem can to some extent be less by adding more diffusion but turn out to be problematic anyway. More than 20% of the rooms have a room ratio of over 1:2, more than 45% have a room ratio of more than 1:1,6.

Our experience is that the room ratios are not enough focused in NS 8178, and we hope that this can be further investigated in the ISO standard. There are also challenges, especially in smaller rehearsal rooms, with room ratios between 1:1 and 1:1,2, as discussed by Jens Holger Rindel in his recent paper [14].

Another problem we all too often see is stages with too small openings. This was a standard way to build stages 50 years ago, but we still see these (often) small scenes with walls on both sides towards the audience and a low stage opening also in buildings from the last 20 years. This might come from a misunderstanding that the theatre wants such stages and stage openings, but the fact is that also the theatre people do not like these fixed constructions limiting the stage opening. We see no reason why we cannot have full stage opening - when needed the stage opening can be reduced with curtains, this makes the room much more flexible for all purposes.

The last problem we see is that the seating often is too steep. This is the case both for permanent og retractable seating constructions. One of the consequences is that the number of audience is too high in relation to the volume, another that the seating vertical area turns into a strong absorber with no rear wall reflections. This is especially the case when the

ceiling height in the back seat row is too low, not seldom 2,2-2,5 m. The NS8178 minimum height over the rear seat is set to 3,0 m, we feel that this should be an absolute minimum, especially in rooms with flat ceiling.

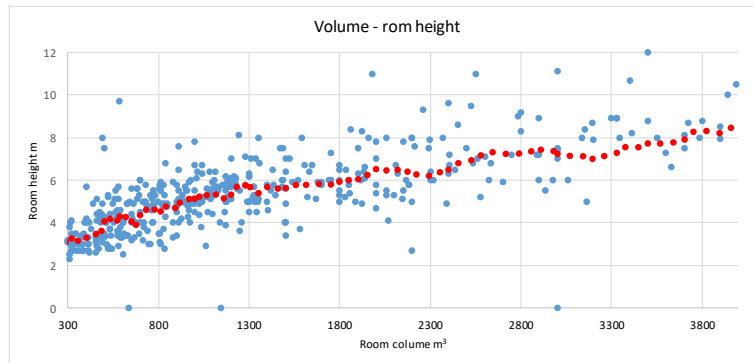


Figure 6: Room volume and room height, volumes  $>300\text{m}^3$  to  $4000\text{m}^3$

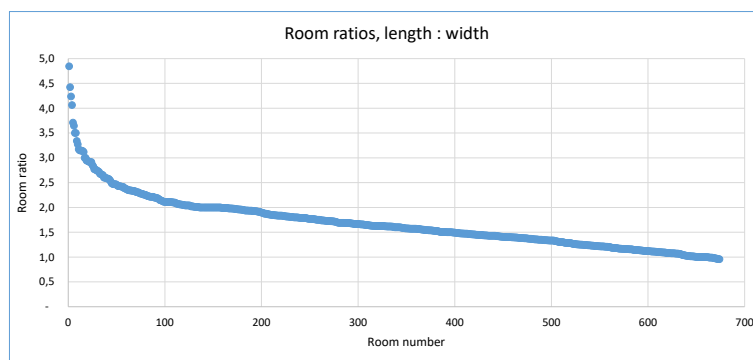


Figure 7: Room ratios, length:width

### 4.3 Reverberation time

The NS 8178 gives reverberation time gives criteria for reverberation time in two aspects

- $T_m$  related to volume and type of music (amplified, loud acoustic and quiet acoustic music)
- Frequency-dependent tolerance limits for factor  $T/T_m$  in octave bands from 63 Hz to 4 kHz relative to the mean reverberation time at the frequency bands 500 Hz and 1000 Hz

The main challenge seems to be to have the owner of the room to prioritize the use of the room. The owners want the room to be multi-purpose, quite often also “all-purpose”. One of our main discussions when planning new music rooms is to explain that different use has different criteria. There are also often needs for non-music use of the room, and this makes the job to prioritise between the different use of the room even more difficult – and important. At the same time, a good process at this stage is essential for having a good project and satisfied users. The NS 8178 determines that multi-use needs special attention, and this is clearly stated: “In such halls, the different applications shall be clearly defined and prioritised. The main intended use and other uses should be specified and made known to the users in order to avoid conflicts in the respect of suitability of the spaces for various applications.” And in such cases, there is need for solutions with variable acoustics. Our experience is that this helps in the process of making the primary and secondary priorities of the room and makes it easier to have good discussions at this point.

Our experience is that the criteria in NS 8178 overall are good guidelines. Combined with the criteria for room volume the reverberation criteria help in finding suitable rooms for different use. We also see that when using the Standard, the rooms planned for music use are better suited than when the Standard is not used. This tells us that the Standard is a good tool and useful in the real world. We experience that the reverberation times given rehearsal rooms for high-volume loud acoustic ensemble could have been somewhat shorter. We recommend that for such use, the reverberation time should be in the lower half of the span, maybe even a bit lower.

The main problem in many of the rehearsal room in use for loud acoustic ensembles is that the reverberation time is way too long, and we see that when lowering the reverberation time, the users are more satisfied. We also see that when the rooms are too small, reducing the mean reverberation time gives less effect.

Another main problem arises for many quiet music ensembles. For these groups, the mean reverberation time is often too short, the result being that several music elements suffer. This has negative influence on the sound production, the timbre and hearing all the other singers or players in the ensemble. This is crucial for developing precise phrasing, equal tonal character and intonation. We see that good performance acoustics for quiet music seldom is prioritised in newly built rooms for music. The multi-purpose use seems to prioritise loud acoustic music and amplified music, leading to fewer and fewer rooms for quiet acoustic music. Many choirs have no other option than to use the churches for concerts. Many churches have acoustics suited for choirs and string music, but not all repertoire is appropriate in a church and choirs want to have their concerts in non-religious rooms.

Our experience when talking to musicians and conductors in acoustic groups is that they prefer rooms with an equal frequency-response, many seem to prefer rooms with a little extra bass and can accept a little shorter reverberation time in the high frequencies. This makes the room sound a bit warmer and the overall timbre a bit more pleasant.

As to the amplified music, many rooms have too long reverberation in the bass frequencies. Especially at 125 Hz too long reverberation time makes the music sound blurry and not tight. To have good music communication between the drummer and the bass player the NS 8178 emphasizes the short reverberation time in the 125 Hz band, and our experience supports this. Rooms that comply with this seems to be preferred by bass players and drummers.

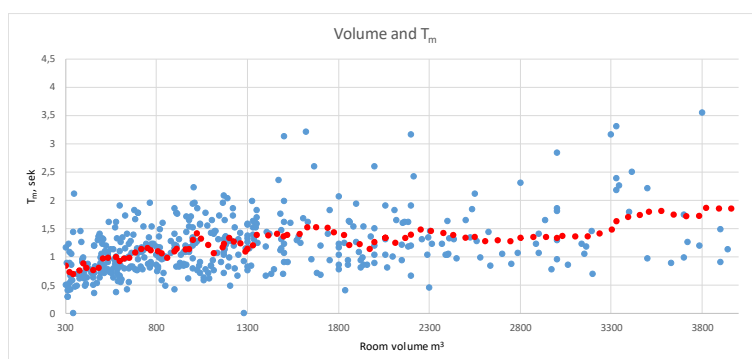


Figure 8: Volume ( $m^3$ ) and reverberation time ( $T_m$ ), volumes  $>300 m^3$  and  $<4000 m^3$

## 4.4 Room strength

The NS 8178 annex A discusses the importance of room strength ( $G$ ). Our experience is that this chapter has been very useful in all kind of rooms. For music instruments which are not electrically amplified, the sound level in the space is determined by

- the type and number of instruments;
- the style of playing, dynamic expression;
- the room volume;
- the reverberation time of the room

Thus, the  $G$  factor combines the room volume and the reverberation time. The focus on room strength in the rehearsal room makes us understand some of the effects of playing or singing in a room with unsuited acoustic conditions. We see that the first and most important criteria is the volume. If the volume is sufficient the reverberation time can be adjusted to satisfy both the need for an appropriate timbre and suitable strength. But if the volume is too small, shortening the reverberation time too much to try to compensate for the lack of volume is negative. On one side, the timbre in the room becomes wrong and unpleasant and can led the musician to try to overcompensate the lack of good sound. On the other hand, the room strength will often still be much too loud. Over the last 6 years, this has been gained and more importance.

Quite many of the rehearsal rooms for wind band have a combination of being too small and too long reverberation time, making the room strength much too high. The best way to solve this and to improve the situation is to find a larger room, and this is often possible. Our experience is that when we explain the need for a bigger room for these groups, situation

often gets better. If moving to a bigger room is not possible, the only solution is to reduce reverberation time, maybe also to combine this with better diffusion. This will also reduce the room strength and help the situation. When planning new rooms, our experience is that the discussion about room strength helps to argue for a bigger room. One of the main effects of NS 8178 is that it's now easier to obtain bigger rooms, to argue for more room volume, for somewhat higher rooms and bit larger room area.

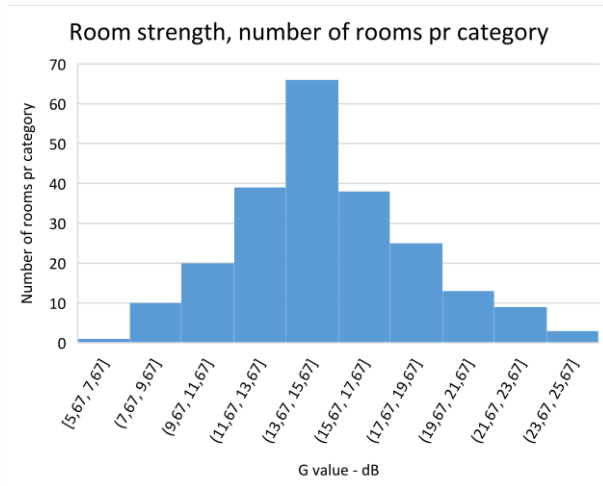


Figure 9: Room strength, pr category

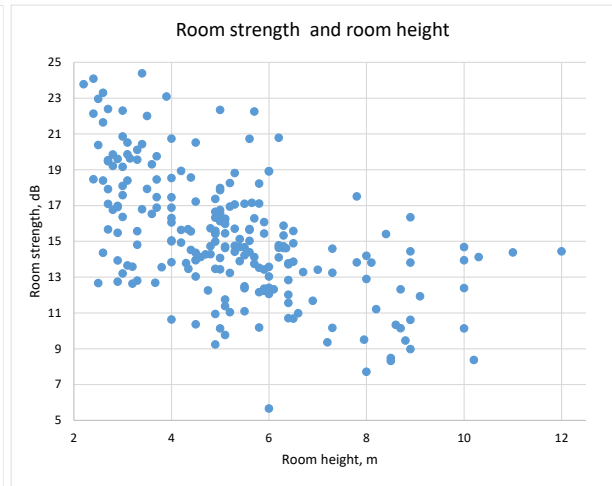


Figure 10: Room strength and room height

## 4.5 Background noise

When all the other criteria are fulfilled the last criteria can spoil it all – the background noise can do much harm to an otherwise well-suited room. Our acoustic measurements show that many rooms have too much background noise. Our experience is that the limits in NS 8178 are quite strong, and that there are not necessarily perceived as a problem if the noise is a little bit higher than in the standard. At least for amplified music and loud acoustic music, the users seem to accept a few dB more.

But, the results from the measurements show that there often are more than just a few dB more than the criteria in NS 8178. The NS 8178 shows to NS8175, class C table 11, for teaching rooms, which has max values of 28 dB  $L_{p,A,T}$  and 30 dB  $L_{p,AF,max}$ . There are many rooms with background noise issues. 42% of the rooms have more than 35 dBA background noise, 20% have more than 40 dBA, these rooms having a real problem.

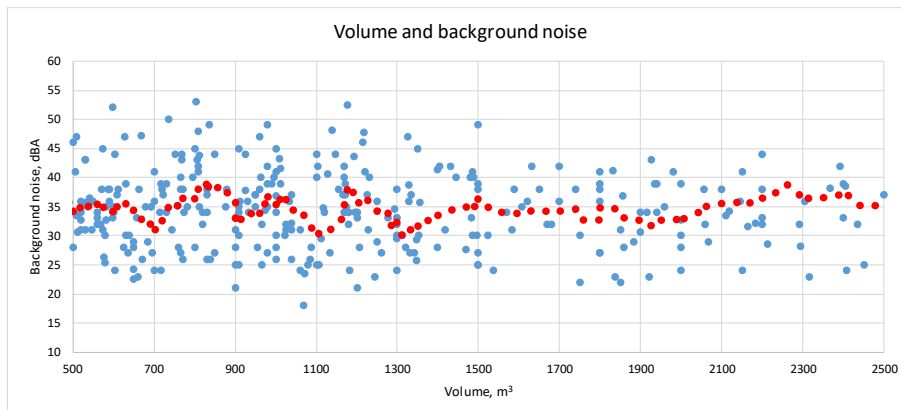


Figure 11: Volume and background noise



## 5 The ISO project: Acoustic criteria for rooms and spaces for music rehearsal

In November 2018, ISO TC 43/SC 2 decided to establish the WG 33 “Acoustic quality criteria for music rehearsal rooms and spaces”; to nominate Mr Jon G. Olsen as convenor of ISO/TC 43/SC 2/WG 33 for a 3 years term from 2019 until end 2021 and to attribute the development of ISO 23591 “Acoustic criteria for rooms and spaces for music rehearsal” to ISO/TC 43/SC 2/WG 33. This was the formal start of the process with a maximum time frame of 48 months which hopefully will lead to an ISO standard for music rooms.

The work is based on the Norwegian Standard NS 8178:2014, which is spread to a large number of countries in 5 continents, including Japan, Korea, New Zealand, Australia, Brazil and USA in addition to a large number of European countries and all Scandinavian countries.

The main objectives listed in the assignment given to the work group are

- Better rehearsal conditions for music, amateurs and professionals
- Most important criteria, different set of standards according to the music the room is being used for
- Help commissioners, consultants, builders, owners and users
- Reduce cost of having to re-build og re-adjust acoustics
- Help assessing the suitability of existing rooms
- Increase the musician’s focus on acoustics and how to deal with different acoustics

The three main purposes are listed as

- To prioritize the use of existing room according to which use they are suited for
- To help in refurbishment projects when the room does not suit the use
- To help build new rooms, in the planning process, to help in the priority process and to help in the project process

Based on the NS 8178 and the experience from using this, the differentiated criteria will be given on the basis of three music types; quiet acoustic music, loud acoustic music and amplified music. Criteria will be given for individual practise rooms, for small ensemble and teaching rooms, for medium size ensemble rooms and for large ensemble rooms. Rehearsal use of recital and multi-purpose rooms are also included. The work has followed the standardized time schedule set by the ISO. The DIS (Draft International Standard) stage was passed in January 2021, and the project is now in the FDIS stage. By April 2021, the project is in the FDIS stage, and the publishing date is set to mid august 2021 if the FDIS passes the final vote stage.

## 6 Summary

The “NS 8178 Acoustic criteria for rooms and spaces for music rehearsal and performance” [3] was first published in 2014, after a working process of three years. The standard was then the first of its kind in the world and was well received both in Norway and in other countries. It is now spread to 5 continents and is widely used. The feedback to Standard Norway have been positive, this is one of the reasons for the proposal to develop ab international ISO standard- This was accepted in September 2018, and the ISO standard is planned to be published late 2021.

The council for Music Organizations in Norway has cooperated with Norwegian acousticians since the 1980s. Since 2009 we have completed over 700 room acoustic reports [5], [6], and on behalf of amateur and professional musicians and conductors there has been more and more focus on the acoustic conditions in rooms both for rehearsal and performance. The NS 8178 has contributed to this and our main experience with the standard is good – we also see that when using the Standard, the rooms planned for music use are better suited than when the Standard is not used. We see that rooms that comply with the standard are better suited for music use than rooms that does not comply with the standard.

Our experience is that the room size is the most important criteria. If the volume is sufficient, the room dimensions, the height and the room ratio are crucial. If this is ok, the acousticians will often be able to adapt the acoustic criteria, such as reverberation mean time, an equal frequency response and strength to the user’s needs. The background noise is also important, we have found that a large proportion of the music rooms have too much background noise.

Fortunately, after publishing the NS 8178 in 2014, we see that it’s now easier to obtain lager rooms and better understanding for the importance of good room dimensions. Many regions and local municipalities have decided to use the NS 8178 [13], and in the “Meld. St. 10 (2018-2019) Report to the Storting (white paper): Voluntary sector – strong,

independent, diverse” [8] one of the main focus areas for the Norwegian government is “enough and well suited rooms for cultural use”.

The acoustic conditions in rooms for music use in Norway is improving, partly due to the NS 8178.

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