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Acoustic quality criteria for music rehearsal rooms and spaces

Critères de qualité acoustique pour les salles et locaux de répétition musicale

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The acoustic properties of a room are crucial for the interaction between the room and the musical instrument. When the acoustic response of a room works well with the instrument, good conditions are achieved for both audience and musicians.

There is a clear connection between the intended use of a music room, the type of music, the ensemble type and the size of the room. It is not possible to achieve satisfactory acoustic conditions for all music types and speech communication in a single room since the acoustic requirements for each use are different.

It is necessary to divide the spaces in accordance with their function and number of musicians or singers (both amateurs and professionals). There are different needs when it comes to the physical size of the room (net volume), timbre, reverberation, net room height and room geometry. The division into types of rooms in this document reflects the practical conditions in musical performance. The musicians play or sing individually (rehearsing or receiving teaching), in small groups (either with the same instruments, voices or in ensembles of three to six persons), in medium size groups/ensembles or in large groups/ensembles (choirs, marching bands, big bands, orchestras and other ensembles), see Reference [22].

The document describes criteria for any kind of rooms and spaces used for music rehearsal. The rooms used for music purposes vary from small practice rooms for one or a few musicians to very large rehearsal rooms and concert halls. In large concert halls, skilled acousticians are engaged for designing and planning the acoustics. In the practice rooms and rooms used for rehearsal or more unformal music performances, the acoustic environment is often not suited for this purpose.

This document is intended for municipalities and county councils, property developers, builders, consultants, architects, contractors, facility owners (public and private) and others who operate or own such buildings. The document may also be used by others, from the individual musician to large groups and associations. A large number of rooms and spaces are used for music rehearsal and performance in municipalities. It is important for property developers to emphasise participation by typical users of the building and the music rooms as early as possible, preferably during the conceptual or planning stages, of which this document should form one of the premises.

Annex A provides guidelines for determining the sound pressure level at forte applying the sound strength (G) of the room and the average sound power level at forte of the musical instruments in question. This leads to favourable range of net room volume and reverberation time for a certain ensemble type. Annex B provides guidelines concerning user processes for planning of rooms for music rehearsal.

Acoustic quality criteria for music rehearsal rooms and spaces

1 Scope

This document specifies differentiated criteria for acoustic conditions and characteristics for rooms and spaces used for music rehearsal. The criteria are specified for different types of music, regardless of the type of building in which the spaces are located. The document provides criteria for room acoustics in spaces used for music rehearsal, whether this is the primary use of the spaces or they are multi-purpose spaces. Together with the acoustic criteria, requirements are given for net room height, net room volume and net area.

Criteria for acoustic conditions are differentiated on the basis of three music types: amplified music, quiet acoustic music, and loud acoustic music.

This document is applicable to the planning of new buildings and the refurbishment of existing ones. The document can also be used to assess the suitability of existing spaces for different musical purposes. The document can be used for the adjustment of rooms and spaces whose primary purpose is not music rehearsal such as sports halls, classrooms, assembly halls, multi-purpose rooms, etc. Flexible acoustic solutions can be used in order to cover several purposes of use.

The criteria in this document do not apply to large, specialized concert halls, opera venues and similar spaces which are basically designed for concerts and performances, or specialized music recording studios.

The document does not deal with the need for logistics, storage rooms for instruments and other key support functions relating to music rehearsal. Sound insulation criteria are not included in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3382-1, *Acoustics — Measurement of room acoustic parameters — Part 1: Performance spaces*

ISO 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

ISO/PAS 20065, *Acoustics — Objective method for assessing the audibility of tones in noise — Engineering method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
diffusor
sound-reflecting surface which spreads the sound in many different directions

3.2
rehearsal room
<music> room for practising individual musical skills, teaching and ensemble rehearsal

3.3
individual practise room
<music> room or studio designed for practising individual musical skills for one to two persons

Note 1 to entry: Individual practise rooms are too small for teaching.

3.4
ensemble room
<music> *rehearsal room* (3.2) for three or more musicians or singers

3.5
recital room
<music> a room where performances or concerts take place

Note 1 to entry: Usually, the performances have relatively few musicians.

3.6
reverberation time
T
time that would be required for sound pressure level to decrease by 60 dB after the sound source has stopped

Note 1 to entry: The reverberation time is expressed in seconds.

Note 2 to entry: T can also be evaluated based on a smaller dynamic range than 60 dB and extrapolated to a decay time of 60 dB. It is then labelled accordingly. Thus, if T is derived from the time at which the decay curve first reaches 5 dB and 25 dB below the initial level, it is labelled T_{20}. If decay values of 5 dB to 35 dB below the initial level are used, it is labelled T_{30}.

Note 3 to entry: The average of reverberation times at the octave bands with the centre frequencies 500 Hz and 1 000 Hz is labelled T_{mid}.

[SOURCE: ISO 354:2003, 3.2[3], modified - Notes 1 and 2 to entry are added from ISO 3382-1:2009, 3.5, Note 3 to entry is added.]

3.7
echo
a sound wave that has been reflected or returned with sufficient magnitude and delay to be detected as a wave distinct from that directly transmitted and distinguishable as a repetition of it

[SOURCE: ISO 2041:1990, 2.71[6]]

3.8
flutter echo
periodic recurrent sound reflections, for example between two parallel sound-reflecting surfaces

Note 1 to entry: In case of short distance between the surfaces, colouration of the sound can be heard. Colouration is an audible accentuation of certain frequencies and may be caused by periodic recurrent sound reflections at short time intervals. In larger rooms, where the distance between the surfaces is large, the phenomenon can be heard as a rustling or rattling sound.

3.9
amplified music
music that is transmitted through an amplifier or sound reinforcement systems

Note 1 to entry: Sound reinforcement systems are often referred to colloquially as "PA equipment". PA is an abbreviation of "public address". PA equipment is normally used for audio reproduction of speech or recorded music.

3.10
sound level
measure for the energy of sound

Note 1 to entry: In this document, sound level is given by the measures A-weighted time-averaged sound pressure level, $L_{p,\mathrm{A},T}$, A-weighted maximum sound pressure level, $L_{p,\mathrm{AFmax}}$, or as octave band levels, L_{oct}.

3.11
sound diffusion
reflection of sound waves in many different directions

3.12
loud acoustic music
music generated by acoustic instruments (non-amplified) that produce music with sound power levels higher than or equal to 95 dB at forte

Note 1 to entry: Examples of instruments are brass (wind) instruments, percussion, piano, big band, and opera singing.

3.13
quiet acoustic music
music generated by acoustic instrument (non-amplified) that produce music with sound power levels lower than 95 dB at forte

Note 1 to entry: Examples of instruments are such as woodwind instruments, string instruments, and singing.

3.14
net average room height
$\bar{h}$
<music room> average of the interior room height measured from the floor surface to the surface of a ceiling above the net area of a room

Note 1 to entry: If there is an acoustically non-transparent suspended ceiling, for music rooms the net room height is measured up to it. There may be national regulations that have other definitions.

3.15
net area
<music room> net floor area limited by the inner surface of the enclosing walls

3.16
net volume
volume calculated from the inner surfaces of enclosing structures (floor, walls, ceiling) except structural parts, shafts, chimneys, etc.

Note 1 to entry: Recesses, projections of an aesthetic nature, profiles and other secondary structural parts are not taken into account in the net volume. Enclosed volume above the suspended ceiling is not included. The volume under a telescopic stand (also called retractable seating or risers) is not taken into account in the net volume.

3.17
sound strength
G
acoustic response of a room specified as sound pressure level from an omnidirectional sound source relative to the sound pressure level from the same sound source at a distance of 10 m in a free field

Note 1 to entry: Sound strength is stated in decibels (dB). Sound strength can vary within the room, and the objective is to achieve as even amplification in the room as possible. A more detailed description of the criterion for sound strength is provided in Annex A.

[SOURCE: ISO 3382-1:2009, A.2.1]

3.18
room resonance
modal resonance
resonance where the excitation frequency coincides with the natural frequency of one of the room modes

Note 1 to entry: A room has many room resonances which occur at different frequencies. At the first room mode, the largest dimension of the room equals one half the wavelength.

3.19
variable sound absorber
sound absorbing curtain, banner, transformable element, or device which can adjust the acoustic absorption within a room

Note 1 to entry: Variable sound absorbers may be used to provide adequate acoustic flexibility. Such elements may also have diffusing or reflecting characteristics.

3.20
tonal sound
sound characterized by a single frequency component or narrow-band components that emerge audibly from the total sound

[SOURCE: ISO 1996-1:2016, 3.4.9[4]]

3.21
sound power
P
rate per unit time at which airborne sound energy is radiated by a source

Note 1 to entry: In this document, the sound power is expressed in milliwatts (mW).

Note 2 to entry: This definition is technically in accordance with ISO 80000-8:2020, 8-9[9].

3.22
sound power level
L_W
ten times the logarithm to the base 10 of a ratio of the *sound power* (3.21) radiated by a source to the reference sound power 1 pW

Note 1 to entry: The sound power level is expressed in decibels.

Note 2 to entry: This definition is technically in accordance with ISO 80000-8:2020, 8-15[9].

Note 3 to entry: In this document, no frequency weighting is applied to the sound power levels.

4 General criteria

4.1 Quiet acoustic music

Quiet music means music that is performed primarily on quiet acoustic music instruments or singing, see 3.12. Typical groups are choirs, vocal ensembles, folk groups, string quartets, string orchestras and groups with string instruments (such as guitars) without amplification.

In rooms for quiet acoustic music, it is generally important to take care of the following:

— appropriate room size (net volume and net area);

— appropriate net room height;

— reverberation adapted to the purpose, the reverberation time as a function of frequency does not vary too much, see 5.7;

— control of repeated reflections, inclining of surfaces, sound diffusion and sound diffusing elements in order to avoid flutter echo;

— sound strength adapted to sound power of the ensemble;

— low background noise level.

Table 1 gives an overview of important properties of rehearsal rooms for quiet acoustic music. Table 4 gives an overview of important properties of recital rooms for rehearsal use for quiet acoustic music.

4.2 Loud acoustic music

Loud music means music that is performed on acoustic instruments that generate a powerful sound, see 3.11. Typical groups are brass bands, concert bands, big bands and symphony orchestras with a wind group. Percussion and opera singing belong to this category as well. The number of the musicians affects the need for floor area, net volume and the overall size of a room.

In rooms for loud acoustic music, it is generally important to take care of the following:

— appropriate room size (net volume and net area);

— appropriate net room height;

— reverberation adapted to the purpose, the reverberation time as a function of frequency does not vary too much, see 5.7;

— control of repeated reflections, inclining of surfaces, sound diffusion and sound diffusing elements in order to avoid flutter echo;

— sound strength adapted to the sound power of the ensemble;

— not too high background noise level.

Table 2 gives an overview of important properties of rehearsal rooms for loud acoustic music. Table 4 gives an overview of important properties of recital rooms for rehearsal use for loud acoustic music.

Pipe organs need special consideration although they belong to loud acoustic music instruments. The design of the organ should meet the size of the room. Other instruments, as Japanese drums or percussion ensembles, also need special consideration.

Grand piano belongs to the group of loud acoustic music instruments, but this does not apply if the piano is used for simple accompaniment or other quiet activities.

4.3 Amplified music

Amplified music includes all music which is transmitted through amplifying or sound reinforcement system, e.g. pop and rock, electronica, jazz, vocal groups, big bands and musicals or similar, where the sound is mainly transmitted through amplifying equipment.

For rehearsal, quiet acoustic and loud acoustic music groups can also be amplified by using microphones. These are included in amplified music if the majority of the sound volume is transmitted through the loudspeaker system. It should be considered to what extent the sound reinforcement system does create the total sound pressure level in the room.

Big band is normally included in loud acoustic music since the sound production is primarily acoustic. Big band may however be included in amplified music when all the wind instruments are amplified.

In rooms for amplified music, it is generally important to take care of the following:

— appropriate bass absorption;

— short reverberation time, the reverberation time as a function of frequency does not vary too much, see 5.7;

— control of repeated reflections, inclining of surfaces, sound diffusion and sound diffusing elements in order to avoid echo;

— not too prominent room resonance;

— not too high background noise level.

Table 3 gives an overview of important properties of rehearsal rooms for amplified music. Table 4 gives an overview of important properties of recital rooms for rehearsal use for amplified music.

NOTE The criteria for rehearsal spaces, also used for recital, for amplified music are based on Reference [18].

5 Criteria for rooms for music rehearsal

5.1 General

Rehearsal rooms are divided by type of music (amplified, loud acoustic or quiet acoustic music) and type of ensemble (number of musicians). The division is made into individual practise rooms, small ensemble rooms, medium and large ensemble rooms. These room types are divided in accordance with different requirements as to room size (net volume, net area, net room height, room geometry), room acoustics (reverberation time, sound absorption, sound reflections) and other needs which distinguish the music types. The division relates to whether the musicians play or sing alone (individual rehearsal or teaching), in small groups (either with the same instruments, voices or in ensemble of three to six persons) or in large groups (choir, marching band, big band, orchestra, etc.)

Rehearsal uses of recital rooms are divided according to the music types; amplified, loud acoustic and quiet acoustic music.

Tables 1, 2, 3 and 4 define the criteria for properties of the different room types.

Acoustically, a music room is like an extension to the musical instrument that is being played in the room. This is particularly pronounced for singing and musical instruments without inherent reverberation, like wind instruments. Sound strength, G, and other acoustic properties of the room are crucial for the interdependence between the room and the musical instrument[19]. If the sound strength of the room is too low, the music will sound weak and the musician may try to compensate by forcing the playing, which may lead to harsh sound quality and decreased dynamic range of the music. On the other hand, if the sound strength is too high, the music will sound too loud and the musician may restrain their playing, which in turn will decrease the dynamic range of the music. When acoustic response of the room works well with the instrument, good rehearsal conditions are achieved for the musician. It is

