

DRAFT INTERNATIONAL STANDARD

ISO/DIS 23591

ISO/TC 43/SC 2

Secretariat: DIN

Voting begins on:
2020-10-14

Voting terminates on:
2021-01-06

Acoustic quality criteria for music rehearsal rooms and spaces

ICS: 91.120.20

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[ISO/DIS 23591](https://standards.iteh.ai/catalog/standards/sist/1461f64a-61a7-4f77-a230-b1aae789c7a0/iso-dis-23591)

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Reference number
ISO/DIS 23591:2020(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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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), room timbre (reverberation time), 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 [21].

The document describes criteria for rooms used for music rehearsal in any kind of rooms and spaces in buildings. 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 informal 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](#) (informative) 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](#) (informative) provides guidelines concerning user processes for planning of rooms for music rehearsal.

The bibliography at the end of this document provides references to other relevant literature.

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Acoustic quality criteria for music rehearsal rooms and spaces

1 Scope

This document specifies differentiated criteria for acoustic conditions and characteristics for 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 music and loud music. Definitions of these are given in [Clause 3](#).

The document is intended to be used in 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 are not intended to be applied to large, specialized concert halls, opera venues and similar spaces which are basically designed for concerts and performances.

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 <http://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} .

[SOURCE: ISO 354:2003, with Notes 1 and 2 to entry are added from ISO 3382-1: 2009]

3.7 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.

3.8 amplified music

music that is transmitted through an amplifier or SR equipment

Note 1 to entry: SR equipment is often referred to colloquially as "PA equipment". SR is an abbreviation of "sound reinforcement" and refers to the amplification of live music performance. PA is an abbreviation of "public address". PA equipment is normally used for audio reproduction of speech or recorded music.

3.9 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, $L_{p,A,T}$, A-weighted maximum sound pressure level, $L_{p,A,Fmax}$, or as octave band levels, L_{oct} .

3.10 sound diffusion

reflection of sound waves in many different directions

3.11**(acoustical) loud music instrument**

acoustic instrument that generates 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.

3.12**(acoustical) quiet music instrument**

acoustic instrument that generates 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.

3.13**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, the net room height is measured up to it. There may be national regulations that have other definitions.

3.14**net area**

area limited by the inner surface of the enclosing walls

3.12**net volume**

V

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.

3.15**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 criteria for sound strength is provided in [Annex A](#).

[SOURCE: ISO 3382-1:2009, Annex A.2]

3.16**room 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 resonance, the largest dimension of the room equals one half the wavelength.

3.17

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.

3.18

volume index

k

room volume per person

Note 1 to entry: The volume index is expressed in cubic metres per person.

[SOURCE: DIN 18041:2016, 3.17]

3.19

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 General criteria

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4.1 Amplified music

Amplified music includes all music which is transmitted through amplifying or sound reinforcement (SR) equipment, 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 and loud 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 SR equipment does create the total sound pressure level in the room.

Big band is normally included in acoustic loud 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, diffusion and sound diffusing elements in order to avoid echo;
- not too prominent room resonance;
- background noise level.

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

NOTE The criteria for rehearsal spaces, also used for recital, for amplified music are based on reference [17].

4.2 Acoustical loud music

Loud music means music that is performed on acoustic instruments that generate a powerful sound, see 3.10. 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 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, diffusion and sound diffusing elements in order to avoid flutter echo;
- sound strength adapted to the sound power of the ensemble;
- background noise level.

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

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

Piano belongs to the group of acoustical loud music instruments.

4.3 Acoustical quiet music

Quiet music means music that is performed primarily on acoustically quiet instruments or singing, see 3.11. 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 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, diffusion and sound diffusing elements in order to avoid flutter echo;
- sound strength adapted to sound power of the ensemble;
- low level of background noise.

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

5 Criteria for rooms for music rehearsal

5.1 General

Rehearsal rooms are divided by type of music (amplified, loud or quiet 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 people) or in large groups (choir, marching band, big band, orchestra, etc.)

Rehearsal use of recital rooms are divided according to the music types; amplified, loud and quiet 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^[18]. 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 important to consider sound strength (G) to avoid risk of hearing damage or hearing loss. Appropriate sound strength will assure the right quality of music rehearsal and recital as well. Informative [Annex A](#) describes the relationship between sound strength, reverberation time and net room volume.

Together with sound strength (G), the main criteria used in this standard is reverberation time (see [5.7](#)), which is a common and easily measurable parameter. However, when designing rooms for music, avoiding several other issues might be equally important; room resonances, colouration due to early reflections, flutter echoes, harshness due to playing directly towards a close, reflecting surface, positions of musicians etc. Such issues tend to be more important in small rooms. Most of these issues can be analysed by inspection of the impulse responses, see ISO 18233^[7].

In order to achieve a smooth frequency response in the bass range, it is desirable to have a favourable proportion between room dimensions, especially in rooms smaller than 300 m³. Ratios of 1:1 and 1:2 between room dimensions should be avoided. The ratio between width and length of the room should not exceed 1:1,6. See [B.2](#) for more guidance.

Flutter echo and other echo and focusing effects (see [3.6](#)) should be avoided. Within each main category of music rooms, variable acoustics may be needed. Some control of low frequency sound, either in the form of absorption, diffusion or scattering is necessary as well. For music rooms, the requirements to background noise given in the tables, apply. For other types of rooms and spaces whose primary purpose is not music rehearsal, requirements to background noise from service equipment stated for the different spaces or room types apply. In such rooms and spaces, every effort should be made to achieve equally good acoustic conditions as in music rooms.

The background noise from service equipment shall not exceed the tabled values for the different room types. Tonal sound of the noise (ISO/PAS 20065) is especially critical in music rooms, and it shall be avoided. Background noise from other service equipment and from outside noise sources shall be subjected to special assessment. See [6.2](#) for requirements for background noise level.