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The new standard DIN 18041 – acoustic quality in rooms

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Abstract

The since 1968 well established DIN18041 standard was revised from October 2013 to mid2015 to commit the room acoustic requirements for the implementation of the inclusion in thefield of hearing and to take into account trends in modern architecture. In addition to thesetechnical and social aspects DIN 18041 with the new title “Acoustic quality in rooms –requirements, recommendations and instructions for planning” of 2016 gives clarificationsand additions as well as deletions compared to the 2004 edition. The revision of DIN 18041provides clear and unambiguous guidelines described as requirements andrecommendations for everyday rooms where the mutual listening and understanding but alsofinding quietness is significantly important.

Keywords: class room acoustics, standards, DIN 18041

The new standard DIN 18041 – acoustic quality in rooms

1 Introduction

The DIN 18041 standard “Acoustic quality in small and middle-size rooms” was published for the first time in 1968. It is clear that with this standard, the well-established knowledge in the area of acoustics in everyday rooms was summarised and made available as a basis for planning in a regulatory way. At the time, it was already indicated in the foreword and in the scope of application, that the standard doesn’t cover “the xcoustic qualityin rooms with specific requirements, for example for high-quality recording and rendering of music and speech”.

Just like the present revision, the revision of the years 2000 to 2004 maintained the decision that the standard should not cover concert halls, churches, studios and other rooms of particular high acoustic quality.

With the version of 2004 [2] a differentiation in function of rooms in category A and category B, which in the 1968 version were called category 1 and category 2, was accomplished. Further, the 2004 version introduces the assignment of category A rooms to five types of usage. This differentiated approach was maintained in the present revision, adjusted in its content and extended to rooms of category B.

Since the revision of the DIN 18041 standard of the years 2000 to 2004, a series of changes in building techniques but also societal-political topics have arisen, which required a new revision. The requirements in the area of barrier-free construction and the inclusion in the area of education can be mentioned as reasons that have contributed to the continued documenting and completion of the regulatory framework in room acoustics. Proven concepts were taken over in the new version of the standard, whereas ambiguities and room for interpretation were addressed and obsolete parts were removed.

2 New version of 2016

The theory of the micro-perforated panel absorber as initially presented in (Maa, 1975) is based on the classical treatment of sound propagation in short tubes. The derivation by Maa (Maa, 1975) first delivers an approximation for the specific acoustic impedance ZMPP for a micro-perforated panel of thickness t with holes of diameter d spaced at a distance b apart in front of an air cavity with a depth D, see Figure 1 for principal set-up.

The new DIN 18041 standard is entitled “acoustic quality in rooms – requirements, recommendations and indications for planning”[3]. The previously existing volume reference of small and middle-size rooms is abandoned, whereby the new direction chosen in a number of parts is described.

As was already the case in 1968 and 2004, the acoustic quality as an acoustic property of a room is defined as follows: “suitability of a room for specific sound performances, in particular for appropriate speech communication and musical performance in places according to the room’s usage.

The differentiation between the room categories A and B is also maintained. The room category A covers rooms, in which the acoustic quality over a long and medium distance is guaranteed thanks to the adjustment of the reverberation time and sound direction in function of the usage. In rooms of category B the acoustic quality over a short distance is ensured through appropriate damping of the room. Within each of the categories of rooms five types of usage are distinguished. This is new for category B rooms; for the category A rooms there are changes. Below we will develop this in detail.

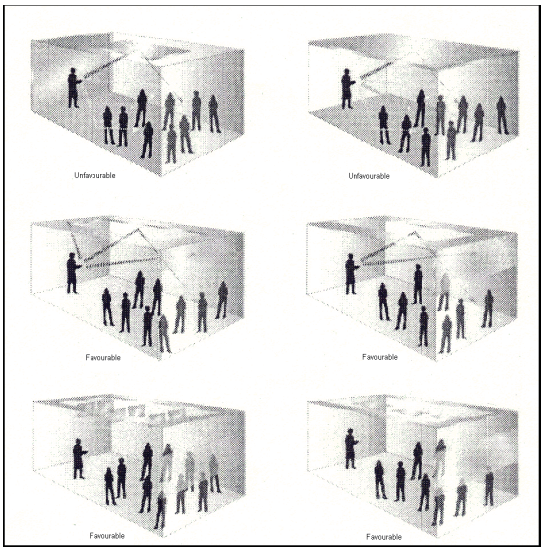

Image 1 favourable and unfavourable distribution of sound absorption areas (marked in yellow) at the ceiling as well as at the back wall according to the 2016 DIN 18041 standard from [9].

The instructions concerning the geometric design of rooms or also the volume indicator have been maintained and updated and summarised in DIN 18041 [3] under point 5, with only few changes and updates. The favourable and unfavourable distribution of absorption areas in the room (see image 1) have changed as little since 2004 as the favourable and unfavourable room shapes.

Room category A

The five usage types of room category A are being denoted as A1 to A5. The names of the usage types, that we can practically qualify as ‘historical’ are being maintained resp. completed as shortnames:

- Usage type A1 – “Music”,
- Usage type A2 – “Speech/presentation”,
- Usage type A3 – “education/communication”,
- Usage type A4 – “education/communication inclusive”,
- Usage type A5 – “sport”.

The target values for the reverberation time, short Ttarget, are shown for each of these five usage types graphically and in a formula in function of the room's volume (image 2). Typical volume values for each usage type are shown as a solid line. Examples of rooms for the usage types are indicated (Table 1).

As was already the case in the 2004 version, there are again five usage types, whereby the sports rooms are bundled into one usage type, previously "sports 1" and "sports 2". The usage type A4 has lately been added and takes over the remark, which was already present in the 2004 version, that for people with a greater need for speech intelligibility the reverberation time of the previous usage types "education"/"speech" is to be decreased by up to 20%. This new usage type A4 explicitly addresses in a specific way the interests of people who suffer from hearing impairment.

Besides the target value of the reverberation time, the new DIN 18041 [3] sets a prescription for the reverberation time in function of the frequency. The distinction, that was made so far between the different usage types "speech" and "music" (education strictly spoken not being included), is abolished and for the usage types A1 to A4 a harmonised tolerance is instaured (image 3). The frequency dependent reverberation time has to be within the tolerance margin. The proof that the frequency dependent reverberation time is respected, is delivered based on the instructions of the newly introduced appendix A.

The requirements with regards to the frequency dependent reverberation time relate to the occupied condition of the room, whereby the room is deemed to be occupied at 80% of its standard occupation. The ever incorrectly interpreted remark in the 2004 version ([2], page 13) that the reverberation time in the unoccupied room should not be more than 0,2 s over the target value (accepted exceeding the tolerance margin in the unoccupied room), is now completely omitted.

As before, the reverberation time requirements are considered for the frequency range from 125 to 4000 Hz octave centre frequency. A comprehensive research and discussion about the extension of the frequency range were concluded in consensus between the interested specialist groups on the remark, that the extension of the existing frequency range of the 2004 [2] DIN 18041 from 100 to 5000 Hz in 1/3 octave band width is not being considered necessary for the rooms in scope of the standard.[1]

An extension of the standard's frequency range isn't useful considering the standards for measurement of sound absorption (DIN EN ISO 354 [5]) and room acoustics parameters (e.g. DIN EN ISO 3382-2 [6]). Indications for an extended frequency range are presented for information and orientation purposes as was the case in the 2004 edition (see lines in image 3).

[1] 1 See the joint statement about low frequencies in room acoustics of DIN and Deutsche Gesellschaft für Akustik (DEGA).

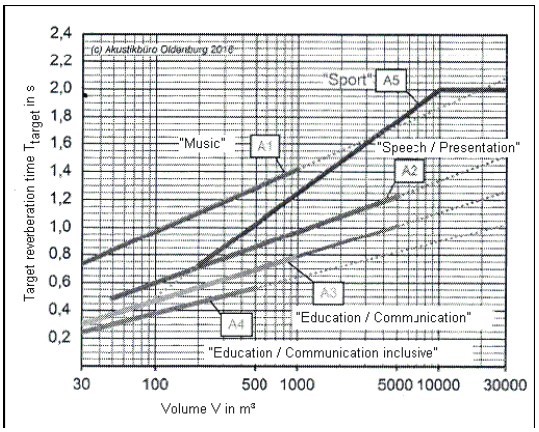

Image 2 Values for the reverberation time Ttarget in function of the room usage and volume

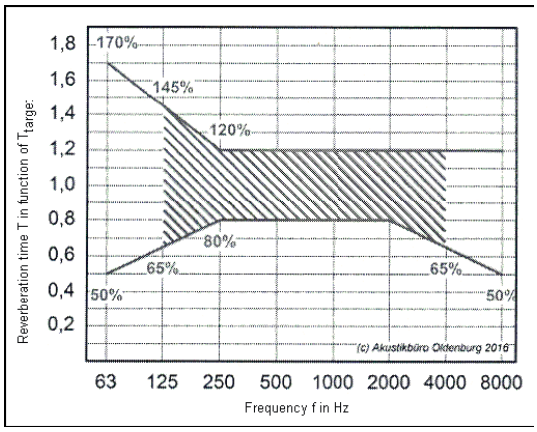

Image 3 Tolerance margin for the frequency dependent reverberation time in function of T_{target}

Room category B

What is new compared to the 2004 edition, is that in analogy with the approach for room category A, the category B rooms are subdivided into five usage types. The related descriptions and examples are shown in table 2. For category B rooms, recommendations for damping the room are made in the form of guide values for the ratio between the room's absorption area A and the volume V. The fixed A/V-values for a medium clear height h of up to 2,5 m are shown in Table 3; for greater room heights, a decreased A/V ratio is recommended (see image 4).

class room acoustics, standards, DIN 18041

Table 1 Usage types of the room category A and examples for rooms with those usage types

Usage type	Shortname and description of the usage type	Examples
A1	Shortname : "Music" Mainly musical performances	Music room with active musical performing and singing
A2	Shortname: "Speech/presentation" speech performances are at the forefront, usually from one single (frontal) position simultaneous communication between several people at different places in the room is seldom held	Court and council hall, community hall, Auditorium Meeting room, School auditorium
A3	Shortname: "Speech/presentation inclusive" Room of the usage type A2 for people, who depend on speech intelligibility Required for inclusive usage	Court and council hall, community hall, Auditorium Meeting room, School auditorium
	Shortname: "Education/communication" Communication intensive usage with several simultaneous speakers spread in the room	Classroom, Differentiation room, Conference room, Discussion room, Seminar room, Gathering room in kindergartens, Care facilities and retirement homes
A4	Shortname: "Education/communication inclusive" Communication intensive usage with several simultaneous speakers spread in the room similar to usage type A3, but for people, who specifically	Classroom, Differentiation room, Conference room, Discussion room, Seminar room,

	depend on good speech intelligibility For rooms bigger than 500m³ and for musical usage this usage type is not suitable Required for inclusive usage[a]	Gathering room in kindergartens, Care facilities and retirement homes Video-conference room
A5	Shortname: “Sports” In sport and swimming halls several groups communicate (also simultaneously) with different content	Sport and swimming halls for nearly exclusive sport usage

[a]The German law about equal opportunities for people with disabilities, comparable regional regulations and the UN convention for people with disabilities imply that new buildings open to the public are to be built in an inclusive way, as long as this can be reached without disproportional effort. Further details can be found in the respective regional laws.

The A/V ratio for the category B rooms is to be considered in function of the frequency in the frequency range relevant for speech between 250 and 2000 Hz in octave bandwidth, i.e. planning is usually done in function of the frequency for four octaves.

The consideration of rooms like “playgrounds and dressing rooms in schools and kindergartens” (usage type B5) but also the rooms for short stays (usage type B2) represent an urgent necessary completion of the standard with the objective to reduce noise in such rooms.

Appendix A – proof of the reverberation time

The proof that the frequency dependent reverberation time is being respected, is delivered according to the instructions of the standard’s new appendix A, whereby it has to be stated upfront, that DIN 18041 is a regulatory framework that sets requirements and makes recommendations, and not a calculation procedure or prescription. Existing calculation and measurement procedures in other regulatory frameworks [6; 8] are referred to.

Table 2 Usage types of room category B and examples for rooms with those usage types

Usage type	Description	Examples
B1	Rooms without quality of stay	Entrance halls, corridors, staircases and such as mere circulation areas in schools, kindergartens, hospitals and care facilities)

B2	Rooms for short stay	Entrance halls, corridors, staircases and similar circulation areas with quality of stay (reception area with waiting rooms etc.) Exhibition halls, Counter areas, Dressing rooms in sports halls
B3	Rooms for longer stay	Exhibition halls with interactivity or increased noise levels (Multimedia, Sound-/video art etc.) Circulation areas in schools and child care facilities (kindergartens, nursery, shelter etc.) Circulation areas with quality of stay in hospitals and care facilities (e.g. open waiting areas), Waiting rooms for patients, Break rooms, Hospital rooms, quiet rooms, Operation rooms, therapy rooms, Examination rooms, consulting rooms, Dining rooms, canteens, Laboratories, Libraries, Salesrooms
B4	Rooms with a need for reduced noise levels and room comfort	Reception/counter area with regular workplace, Laboratories with regular workplace, lending areas in libraries, Distribution areas in canteens, Resident rooms in care facilities, Citizens' office, Office rooms [a, b]
B5	Rooms with special need for reduced noise levels and room comfort	Dining rooms and canteens in schools, child care facilities (kindergarten, nursery, shelter etc.), hospitals and care facilities, Working space with particularly high noise levels

		(e.g. shopfloors, workrooms, canteen kitchens, scullery), Callcentres[a], control centres, security centres, Intensive-care areas, recovery stations, Movement areas in child care facilities, Playgrounds and dressing rooms in schools and child care facilities (kindergartens, nurseries, shelters etc.)

[a] Recommendations for offices as well as callcentres are looked at in detail in the VDI 2569 directive.
[b] Individual offices can be classified as usage type B3.

Table 3 Guide values for the ratio between the equivalent sound absorption area A and the room volume V for the usage types of room category B with a clear room height h ≤ 2,5 m. For greater room heights see image 4.

Usage type	A/V in m²/m³
B1	Without requirement
B2	A/V ≥ *0,15*
B3	A/V ≥ *0,20*
B4	A/V ≥ *0,25*
B5	A/V ≥ *0,30*

During the planning phase the proof of the frequency dependent reverberation time is delivered by calculation and after preparation of the room by measurements. As DIN 18041 [3] is a standard with requirements and recommendations in room acoustics, the remarks for the calculation of the reverberation time in the old 2004 version have been removed.

Following the orientation of the standard, the frequency dependent approach to the reverberation time for the category A rooms is an absolute requirement. For more historical reasons, the requirements related to the reverberation time are based on the occupied state of the room. Measurements however most often do not take place in presence of people in the room. To compensate for this apparent discrepancy, a procedure for the conversion between the unoccupied and the occupied state has been made available with the standard appendix A “proof of room acoustics requirements”. For this purpose the sound absorption area of people is prescribed as a norm.

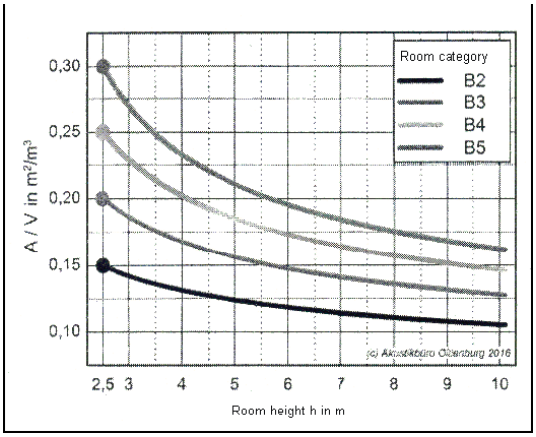

Image 4 Guide values ratio between equivalent absorption area A and room volume V for the usage types B1 to B5.

As proof of the calculation the DIN EN 12354-6 [8] is referred to and it is being highlighted that the calculation can also be carried out with extended calculation methods (e.g. DIN EN 12354-6-Appendix D, numeric methods such as tracing ray paths etc.), if the conditions of an approximate diffuse sound field are not fulfilled. As requirement standard DIN 18041 cannot prescribe the user any method for the proof in the context of room acoustics planning.

Further appendices

During the revision, the discussion about “construction acoustics related requirements”, point 4.2 in [2], took up a lot of space. At first it sounds like a paradox that a room acoustics standard takes a stand about requirements in construction acoustics. On the other hand, appropriately low noise pressure levels are an absolute condition in rooms for good room acoustics or acoustic quality. A multi-layer discussion about the binding nature and the level of noise pressure and its causes in rooms have resulted into this important aspect being documented in the informative appendix B “technical conditions for good room acoustics”. Besides indications for the allocation of rooms in a building and structural measures for protection against noise, maximum noise pressure values for external noise, short LNA,Bau, are given. This indicator, difficult to use from a planning and technical measurement perspective, describes the noise pressure level in the room, produced by external noise, noise from adjacent rooms, building specific installations, sanitary installations and fix installed media equipment. Definitely in the case of noise from users in adjacent rooms, which depends not only on the acoustic insulation between the rooms, but also on the users’ behaviour, a strict standard requirement would have become really complex. And so, recommendations in an informative appendix are definitely an appropriate – and in standards sometimes necessary – compromise.

The appendices C to G of DIN 18041 [3] have been updated and further developed. The appendices “speech communication” (appendix C), “room acoustics recommendations and planning indications for rooms with audio systems” (appendix D), “planning and implementation of electro-acoustic audio systems for speech transmission” (appendix E) as well as “tools for measures for improvement of intelligibility in case of hearing impairment” (appendix F) were updated. The proven “absorption coefficient tables” were clearly elaborated as appendix G. That also allows non-acoustics-experts to be familiarised with the connections of room acoustics.

Deletions compared to the 2004 edition

Because of the revision of the recommendations for the category B rooms the standard doesn’t contain any reference to the proven sound absorption coefficient αw according to DIN EN ISO 11654 [7] anymore. With its initial definition for room acoustics planning, this simplified indicator for sound absorption has turned out to be inappropriate.

Furthermore, the “simplified evaluation for the usage type education”, see point 5.2.1.2.2 in [2] has not been continued, on the basis that this procedure was not used in the practice of room acoustics planning and consultancy.

3 Conclusions

The new version of the proven room acoustics standard DIN 18041 had become necessary, to integrate trends of modern architecture, but also to fix the requirements for room acoustics for the implementation of inclusion in the area of acoustic quality.

The DIN 18041 [2] was and is seen as the generally recognised regulation for technology in the area of room acoustics. The present revision concentrates on clarifications and completions of this overall proven and widely spread and also internationally known regulatory framework. With the new version, the DIN 18041 sets clear and unambiguous prescriptions as requirements and recommendations for everyday rooms. This means a majority of rooms in schools and child care facilities, as well as other rooms, in which mutual hearing and understanding together with quietness are of particular importance [9]. Also in the future, the new DIN 18041 of 2016 [3] will define the recognised rules for technology in the area of room acoustics.

References

[1] DIN 18041: acoustic quality in small and medium-size rooms. Berlin: Beuth Verlag 1968.

[2] DIN 18041: acoustic quality in small and medium-size rooms. Berlin: Beuth Verlag 2004.

[3] DIN 18041: acoustic quality in rooms – requirements, recommendations and indications for planning. Berlin: Beuth Verlag 2016

[4] DIN 18041: Common positioning of the DIN-working group for the revision of the DIN 18041 and the expert committee for construction and room acoustics of the German society for acoustics regarding the topic of lower frequencies in acoustics of small and medium-size rooms. Berlin: DEGA 2014. www.dega-akustik.de/fileadmin/dega-akustik.de/fachausschuesse/bra/dokumente/din_dega_tiefe frequenzen.pdf

DIN EN ISO 354: acoustics – measurement of sound absorption in hall rooms. Berlin: Beuth Verlag 2003 (currently being revised).

[6] DIN EN ISO 3382-2: acoustics – measurement of parameters of room acoustics – part 2: reverberation time in ordinary rooms. Berlin: Beuth Verlag 2008

[7] DIN EN ISO 11654: sound absorbers for applications in buildings – assessment of sound absorption. Berlin: Beuth Verlag 1997 (currently being revised)

[8] DIN EN ISO 12354-6: construction acoustics – calculation of acoustic properties of buildings based on construction components – part 6: sound absorption in rooms. Berlin: Beuth Verlag 2004.

[9] Nocke, C.: Everyday room acoustics – hearing, planning, understanding. Stuttgart: IRB Fraunhofer 2014