DIN 18041 - a German view

Christian Nocke
Akustikbüro Oldenburg, Germany

Summary

DIN 18041 was revised from October 2013 to mid 2015, and published in early 2016 with the new title "Acoustic quality in rooms - requirements, recommendations and instructions for planning", The new edition of the standard includes a number of clarifications, additions and deletions and includes for the first time explicit guidance for room acoustics to address the particular needs of the hearing impaired. This paper presents a summary of the revised standard and reviews some of the considerations behind the various changes made.

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1. Introduction

DIN 18041 standard “Acoustic quality in small and middle-size rooms” was first published in 1968 [1]. With this standard, well-established knowledge acoustics” in everyday rooms was summarised and made available as a basis for planning and design. The foreword to the 1968 standard indicated that the scope of application did not extend to “the acoustical criteria for rooms with specific requirements, for example, high-quality recording rooms for music and speech”. This limitation to “everyday rooms” was continued in the 2004 revision to the standard [2] and is retained in the current edition. Thus DIN 18041: 2016-03 [3] does not provide criteria for concert halls, churches, studios and other spaces where the intended usage has highly specific requirements for acoustic quality. Since 2004, a series of changes in building techniques and social-political expectations have occurred which provided motivation for a further revision. For example, the renewed emphasis on barrier-free/open plan instructional spaces in primary and secondary education can be mentioned as one area where additional guidance was needed.

2. DIN 18041: 2016

DIN 18041: 2016 [3] is entitled “Acoustic quality in rooms – requirements, recommendations and indications for planning”. As was with the 1968 [1] and 2004 [2] versions, acoustic quality as a property of a room is defined as that which determines “the suitability of a room for specific acoustical performance, in particular for speech communication and musical performance according to the room’s usage”.

Room Categories A and B, introduced in the 2004 version of the standard [2], are maintained. Room Category A covers those spaces where the required acoustic quality for the intended room usage, over longer and medium distances is achieved due to adjustment of reverberation time and the directivity of the sound source. For Category B, acoustic quality for spoken communication over short distances is ensured through the provision of appropriately arranged sound absorption to dampen the room response.

Within each of the room categories, five types of usage are distinguished. This is a new feature for Category B; for Category A (which previously included five usage types) there are minor changes of usage type definition.

The instructions concerning the geometric design of rooms (favourable and unfavourable room shapes) and room volume have been maintained with few changes, as has guidance on favourable and unfavourable distribution of sound absorption (see Figure 1).

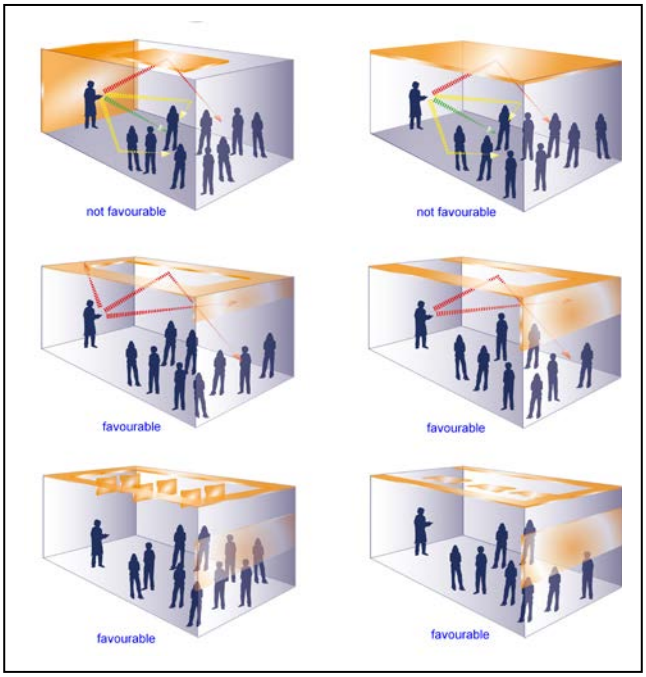

Figure 2. favourable/unfavourable distribution of sound absorption areas in a room.

3. Room Category A

The five usage types for Category A are denoted A1 to A5:

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

Table 1 gives a description of the various usage types with examples of the particular room types and usage included in each classification. As was the case with DIN 18041: 2004 [2], there are five usage types, however in the 2016 revision sports rooms are bundled into one usage type, (the former classifications "Sports 1" and "Sports 2" are abandoned). Usage type A4 has now been added to emphasise the guidance (to some extent already present in the 2004 version [2]) that for situations with a need for improved conditions for speech intelligibility, the reverberation time given for usage types A2 and A3 ("education"/"speech" usage) is to be decreased by up to 20%. In particular, usage type A4 "inclusive" explicitly addresses the requirements of the hearing impaired.

Figure 2 shows the target values for the reverberation time, T_{target}, for each usage type relative to room volume. In addition to overall reverberation target values, DIN 18041:2016 [3] addresses reverberation requirements as a function of frequency and provides that the reverberation time at any given frequency should remain within a required tolerance of the relevant guidance value. (Figure 3). The distinction, which was formerly made between usage for "speech" and "music" (education strictly speaking not being included), is abolished and a harmonised tolerance is given for usage types A1 to A4. The standard provides as Appendix A, guidance as to how its requirements for frequency dependent reverberation time, are to be shown to have been achieved.

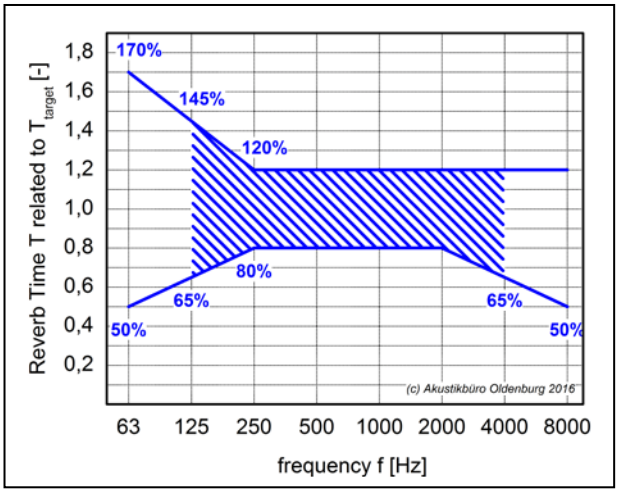

Figure 2. Values for the reverberation time, T_{target} as a function of room usage and volume

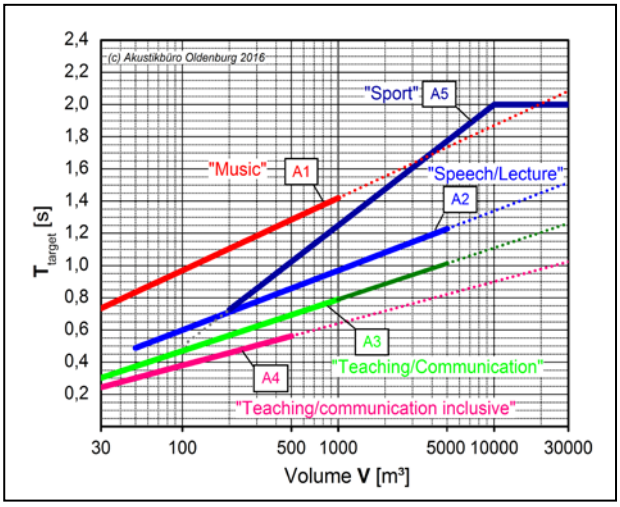

Figure 3: Tolerance range for the frequency dependent reverberation time in function of T_{target}

The criteria for frequency dependent reverberation time relate to the occupied condition of the room, whereby the room is deemed to be

Table 1: Room Category A usage types

Usage type	Description of the usage type	Examples
A1	*Shortname : "Music"* *Mainly musical performances*	*Music room with active musical performing and singing*
A2	*Shortname: "Speech/presentation"* *Spoken presentations, usually from one single (frontal) position* *simultaneous communication between several people at different places in the room is seldom needed*	*Court and council hall, community hall, Auditorium Meeting room, School auditorium*
A3	*Shortname: "Speech/presentation inclusive"* *Rooms with similar usage requirements to Type A2 except that the usual audience may include a high proportion of people with hearing impairment who depend critically for speech intelligibility on good room acoustics* *Shortname: "Education/communication"* *Communication intensive usage with several simultaneous speakers spread throughout the room*	*Court and council hall, community hall, Auditorium Meeting room, School auditorium* *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 except that the usual audience may include a high proportion of people with hearing impairment who depend critically for speech intelligibility on good room acoustics* *This usage type is limited to room volumes less than 500m³. Rooms meeting requirements for this usage are not generally suitable for musical performance purposes.* *Required for inclusive usage*	*Classroom, Differentiation room, Conference room, Discussion room, Seminar room, 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 equal opportunities law for people with disabilities, comparable regional regulations and UN convention for people with disabilities imply that new public buildings are to be built in an "inclusive" way, this can be achieved without disproportional effort.

occupied at 80% of its standard occupation. The remark made in the 2004 version, that the reverberation time in the unoccupied room should not be more than 0,2 s above the target value, is omitted, as having been found liable, to misinterpretation.

As before, the reverberation time requirements are given for the frequency range 125 to 4000 Hz. Comprehensive research and discussions between the interested specialist groups concluded with the consensus, that the extension of the frequency range to 100 to 5000 Hz in 1/3 octave bands was not warranted for room usage types included in the scope of the standard.

Table 2: Room Category B usage types

Usage type	Description	Examples
B1	Non habitable rooms and circulation areas where people will seldom congregate	Entrance halls, corridors, staircases and such in schools, kindergartens, hospitals and care facilities
B2	Non habitable rooms where there may be a need for people to congregate or wait for short periods and where spoken communication may be important	Entrance halls, corridors, staircases and similar circulation areas where people may need to congregate or wait for appreciable periods (reception areas, waiting rooms etc.) Exhibition halls, counter areas, Dressing rooms in sports halls
B3	Non-habitable rooms where people may be expected to congregate or wait for longer periods and where good conditions for spoken communication is likely to be important to the use	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 where people are likely to congregate 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, Residential rooms in care facilities, Public offices, open plan office space[a, b]
B5	Rooms with special needs 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), Call-centres, control rooms, security rooms, 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 open plan offices and call-centres are described in detail in the VDI 2569 directive.

[b] Private offices can be classified as usage type B3.

4. Room Category B

With the 2016 revision of the standard, Room Category B is subdivided into five usage types, the relevant descriptions and room examples are shown in Table 2. For Category B, recommendations for control of reverberation are made in the form of guidance values for the ratio between the room absorption area A and the room volume V. The fixed A/V-values for a median 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 Figure 4). In rooms spread over several floors (e.g. central atriums with open connected floors) the room height, h, refers to the total room height. In

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, see figure 3

Usage type	for room heights $\boldsymbol{h} \leq$ **2, 5 m** in m²/m³	for room heights h $> 2{,}5\ m$ in m2/m3
B1	No requirement specified	None given
B2	A/V ≥ *0,15*	$A/V \geq [4{,}80 + 4{,}69 \lg (h/1\ \mathrm{m})\ ]^{-1}$
B3	A/V ≥ *0,20*	$A/V \geq [3{,}13 + 4{,}69 \lg (h/1\ \mathrm{m})\ ]^{-1}$
B4	A/V ≥ *0,25*	$A/V \geq [2{,}13 + 4{,}69 \lg (h/1\ \mathrm{m})\ ]^{-1}$
B5	A/V ≥ *0,30*	$A/V \geq [1{,}47 + 4{,}69 \lg (h/1\ \mathrm{m})\ ]^{-1}$

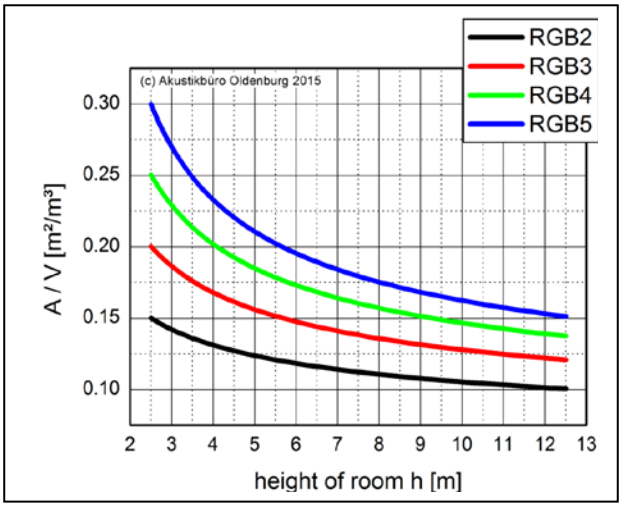

Figure 4: suggested A/V for group B.

general however, the median clear room height h can be calculated by dividing the room volume by the net surface area of the room. The A/V ratio for the category B is to be considered in terms of those frequencies important to speech (specifically, the octave bands, 250 Hz to 200Hz inclusive).

The inclusion of spaces such as "enclosed playgrounds and dressing rooms in schools and kindergartens" (usage type B5) but also rooms where people may need to congregate, wait or rest for appreciable periods (usage type B2) represent necessary additions to the standard to reduce

reverberant levels in what can be very noisy areas.

5. Demonstrating compliance – Appendix A

The standard requires that during the building design phase, likely compliance with the required frequency dependent reverberation time is demonstrated by calculation and after preparation of the room by measurements. In this relation, with the publication of the standard, the guidance on frequency dependent reverberation time for Category A rooms becomes an absolute requirement in new buildings. As DIN 18041:2016 [3] gives both "room acoustic" design criteria and recommendations as to how this is to be achieved in practice, but is not explicitly concerned with measurement, the guidance as to the measurement and calculation of the reverberation time which were provided in the 2004 version, have been removed.

For historical reasons, reverberation time requirements are based on the stated assuming an occupied room. Measurements however most often do not take place in with people present in the room. To compensate for this, a procedure to convert reverberation time measurements (or calculations) made with the room unoccupied, to the situation in the occupied state has been included as Appendix A "Proof of room acoustics requirements". For this purpose the sound absorption area of people is prescribed as a norm.

Appendix A refers to DIN EN 12354-6 [4] and it notes that the calculation can also be made by recourse to more computationally expensive methods such as tracing ray (DIN EN 12354-6-Appendix D), if the conditions of an approximately diffuse sound field are not fulfilled. In this relation as a standard which is primarily concerned with room acoustics design criteria DIN 18041 cannot also prescribe calculation methods.

6. Layout and Construction: Recommendation for good acoustics: Appendix B

During the revision, the discussion about building acoustics related requirements took up a lot of space. At first it sounds like a paradox that a room acoustics standard provides guidance about requirements in building acoustics. On the other hand, appropriately low noise pressure levels are an absolute condition in rooms for good room acoustic quality. Extensive discussions about building. types and the various contributions to noise level within any particular room in a building have resulted in an informative appendix, Appendix B "Technical conditions for good room acoustics". This appendix provides guidance on the layout of rooms in a building for good acoustics and the structural measures required for protection against ingress of external noise and noise from other parts of the building to the particular room under consideration. Maximum, A-weighted sound pressure values for external noise, so-called $L_{NA,Bau,}$ are given. This indicative quantity, which can be difficult to use from a design and noise measurement perspective, describes the sound pressure level in the room, produced by external noise, noise from adjacent rooms, mechanical and hydraulic plant and equipment, sanitary installations and fixed media equipment. In this relation, with 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 been impractical. Thus recommendations in an informative appendix are an appropriate, one might

7. Other matters – appendices C to G

Appendices C to G of DIN 18041 [3] have been updated and further developed. Appendix C Speech communication; Appendix D Room acoustics recommendations and planning indications for rooms with audio systems: Appendix E, Planning and implementation of electro-acoustic audio systems for speech transmission; and Appendix F Tools for measures for improvement of intelligibility in case of hearing impairment, were updated. The "Absorption coefficient tables", given in previous versions were retained and included as Appendix G.

8. Conclusion

The new version of DIN 18041 was motivated by a need to integrate trends in modern architecture but also to enable explicit guidance on requirements for room acoustics suitable for improved inclusion of the hearing impaired to be incorporated in the standard. The revision clarifies guidance in an already proven framework. Clear and unambiguous prescriptions for good room acoustics in everyday rooms are given. This includes the majority of room types present in schools and child care facilities and in other building spaces, with similar requirements for speech and quiet study.

References

[1] DIN 18041 – Hörsamkeit in kleinen und mittelgroßen Räumen (Acoustic Quality in small and medium-sized rooms), Oktober 1968

[2] DIN 18041 – Hörsamkeit in kleinen und mittelgroßen Räumen (Acoustic Quality in small and medium-sized rooms), Mai 2004

[3] DIN 18041 Hörsamkeit in Räumen — Anforderungen, Empfehlungen und Hinweise für die Planung (Acoustic quality in rooms – Specifications and instructions for the room acoustic design), 2016

[4] DIN EN ISO 12354-6 Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements – part 6: Sound absorption in enclosed spaces, April 2004

[5] C.Nocke, Raumakustik im Alltag (Roomacoustics in everyday life), Fraunhofer IRB, 2014