Drywall Systems

AK01.de

Technical Brochure 2018-02

Room Acoustics with Knauf

Basics and Concepts

Cleaneo Classic
Cleaneo Module
Cleaneo Single

Contents

Usage instructions

Notes on the document

This technical brochure is an information document on special topics as well as on the specialist competence from Knauf. The contained information and specifications, constructions, details and stated products are based, unless otherwise stated, on the certificates of usability (e.g. National Technical Test Certificate (abP) and/or German National Technical Approvals (abZ) valid at the date they are published as well as on the applicable standards. In addition, design and structural requirements and those regarding building physics (fire protection and sound insulation) are considered.

The contained construction details are examples and can be used in a similar way for various cladding variants of the respective system. At the same time, the demands made on fire resistance and/or sound insulation as well as any necessary additional measures and/or limitations must be observed.

References to other documents

Technical brochures

- Room Acoustics with Knauf – Data for planning, AK02.de
- Sound insulation with Knauf – Basics, SS01.de
- Sound insulation with Knauf – Interior partitions, SS02.de
- Sound insulation with Knauf – Ceilings, SS03.de
- Sound insulation with Knauf – Exterior constructional components, SS04.de
- Sound insulation with Knauf – Room in room systems, SS05.de

Product data sheets

- Product Data Sheets of the Knauf system components

System Data Sheet

- Knauf Cleaneo Acoustic Board Ceilings, D12.de
- Knauf Cleaneo Acoustic Dropped Ceilings, D14.de
- Knauf Cleaneo Acoustic Wall Systems, AK04.de

Knauf-App TOPview

In the App TOPview you will find interesting aspects on the topics of “Experience Acoustics” and “Measure Acoustics”. The App is available for iOS and Android, refer also to the Knauf Homepage at:
https://www.knauf.de/profi/tools-services/tools/vr-app-topview/

Intended use of Knauf systems

Please observe the following:

Caution	Knauf systems may only be used for the application cases as stated in the Knauf documentation. In case third-party products or components are used, they must be recommended or approved by Knauf. Flawless application of products/systems assumes proper transport, storage, assembly, installation and maintenance.

General instructions

Terms

A/V ratio

Equivalent sound absorption surface A in m^2 in relation to the room volume V in m^3

Attenuation

Good acoustic attenuation of a room is understood as sufficient reduction of the noise level and setting a reverberation time that suits the situation within the room. The higher the figure value of the A/V ratio, the greater the sound absorption surface located in the room and the greater the acoustic attenuation within the room.

Basics

Short introduction to room acoustics

If the neighbour is too loud, the ceilings and party walls between living areas can be acoustically upgraded, and should the sound of traffic on the street be too loud, the window can be closed. But what do you do if the sound source is in the room where you are. This is where room acoustics comes into play. The term noise is simply too general. Within a room it is not just the reduction of the noise level created by the colleagues, making the carefree uproar of children in the kindergarden easier to withstand or to reduce the noise emissions of machines during operation. For some rooms it is necessary to direct the sound to achieve the desired effect.

In auditoria, for example, the primary concern is to provide all of the occupants with sufficient sound energy to ensure that the spoken word can be understood in the furthest away row without any loss in the intelligibility of voices.

Particularly in respect of the architectural trends towards smooth surfaces such as fair-faced concrete, glass and purist furnishing, the requirement for knowledge regarding the necessity of room acoustics is very significant.

Poor room acoustics can cause a whole range of problems with a diverse range of room usages.

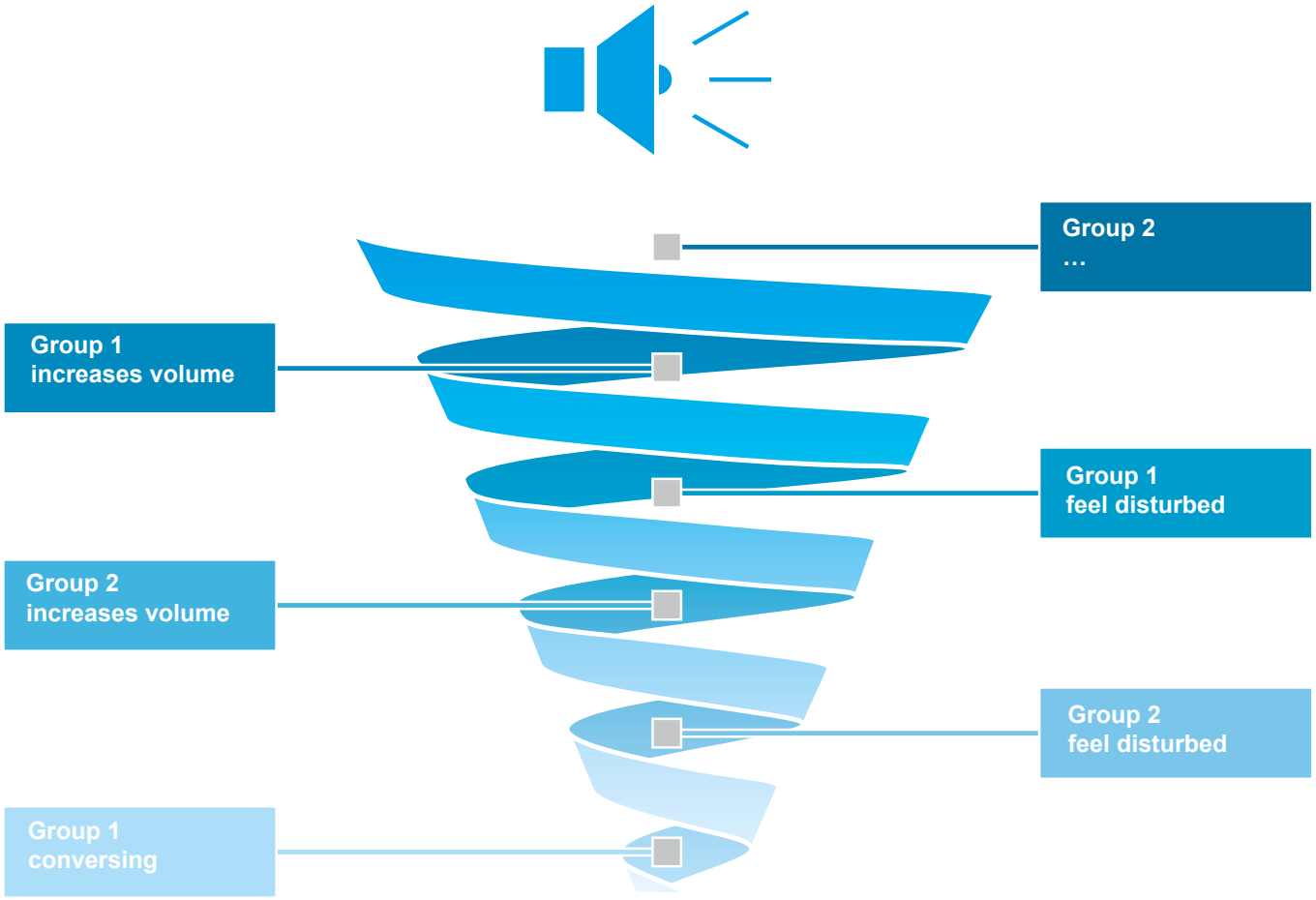
- Sound reflection interference with negative effects on the intelligibility of voices impair the ability to concentrate with verbal presentations.
- Poor provision with primary sound at voice-based events and the loss of comprehension of word and speech leads to agitation and a “background murmur” of those present.
- Superposition of conversations involving several speakers leads to poor room acoustics and to the acoustic quality becoming indistinct, and to an increase in speech volume creating a further worsening of this effect
- No or insufficient consideration of the acoustic quality of the room lead to a higher noise level in enclosed areas and subsequently to
  - Increased demands on the cognitive processes
  - Simply to less reduction in the noise level, even at extended distances
  - Aural (hearing-related or auditory) and extra-auditory (effects of noise on the psyche and organism unrelated to hearing) damage

The loudness spiral

When several speakers are within a room (in schools, offices, restaurants, etc.) with a poor room acoustic quality, a build-up in the noise level will occur due to the following effect:

A group of people are having a conversation. Another group in the vicinity are disturbed by the noise and unconsciously increase the speech volume to continue their conversation without disruption. This will in effect unconsciously cause the first group to raise the volume of their voices so that they can understand one another. Thus the loudness spiral is triggered. The effect is reinforced with the inclusion or each further group. This is for example, the reason why it is difficult to have a conversation in a restaurant or canteen without shouting at the other persons present.

The objective or room acoustical measures must be to guarantee the intended purpose of the room usage and to prevent the occurrence of the loudness spiral.



Significance of the DIN 18041:2004 and DIN 18041:2016

In principle, both the DIN 18041:2004 as well as the DIN 18041:2016 have not yet been introduced in official building regulations. However, reference is made from a whole range of standards and guidelines to this standard. For example in:

- DIN 18040-1: Construction of accessible buildings - Design principles
- Technical rules for workplaces (ASR)
- Certification systems such as the BNB and DGNB

Furthermore, this standard should be viewed as the generally recognized state-of-the-art in sound engineering practice.

A significant difference between the DIN 18041:2004 and the DIN 18041:2016, in addition to the specification or orientation values for the ratio of equivalent sound absorption surface to the room volume, is the provision of instructions for the consideration of the inclusion of people with handicaps. Thus the planning of rooms for verbal presentations/communication requires special attention for persons with special needs to ensure good intelligibility of speech. Accordingly, new buildings should be designed in accordance with the German Federal Equality Law (*Bundesgleichstellungsgesetz*) as well as comparable state building codes and the *United Nations Convention on Rights of Persons with Disabilities.*

Standard-based requirements and recommendations

The reference to the standards in this brochure relate exclusively to the DIN 18041:2004 or DIN 18041:2016 and thus predominantly to a target reverberation time and orientation values for the A/V ratio (equivalent sound absorption surface A ratio to room volume V).

The **reverberation time** T is the time in seconds in which a sound signal introduced to a room requires to reduce the original sound level by 60 dB. A difference of 60 dB corresponds to 1 millionth of the original sound energy.
As it is not always possible to generate this difference owing to external factors, the reverberation time (RT) can frequently be defined in practice as T30 or T20. This means that only the time required to reduce the introduced sound signal by 30 dB or 20 dB is required. A conversion to T60 is undertaken subsequently.

The reverberation time is mainly dependent on:

- Room volumes
- Room geometry
- Surface properties of the room perimeter surfaces
- State of the furnishing

If there are many sound absorbing surfaces in a room, the sound reflection of the introduced sound signal is heavily attenuated and the reverberation time is reduced. Accordingly, there is a fast reduction in the sound energy and the noise level is reduced.
If on the other hand there are no or few sound absorbing materials in a room, the sound reflections will be reinforced and the introduced sound signal and the noise level increase.

In addition to the requirements on the reverberation time there are also orientation values regarding the A/V ratio specified in the DIN 18041:2016. A stands for the equivalent sound absorption surface and V for the room volume. The equivalent sound absorption surface within a room provides an indication of the number of square metres of the total room surface and if necessary includes the furnishings that absorb 100% of the sound energy. The higher the A/V ratio, the higher the attenuation level in the room.

Table 1: Volume indices for diverse main usages of a room

Main usage of the room	Volume index k in m³ per seat
Verbal presentation	4 to 6
Music and verbal presentation	6 to 8
Musical performance	7 to 12
Small musical rehearsal room for up to 10 musicians simultaneously	15 to 20
Larger musical rehearsal room for up to 10 musicians simultaneously	30 to 50

Table 2: Requirements on the reverberation time in dependence on the modes of operation

Room group	Mode of operation	Requirement * $T_{soll} = T_{Target}$
A1	Music	$T_{soll,\,A1} = \left(0{,}45 \log \frac{V}{m^3} + 0{,}07\right)$ s $30\ m^3 \leq V < 1000\ m^3$
A2	Speech/lecture	$T_{soll,\,A2} = \left(0{,}37 \log \frac{V}{m^3} - 0{,}14\right)$ s $50\ m^3 \leq V < 5000\ m^3$
A3	Lessons/communication (up to 1000 m³) as well as speech/lecture (up to 5000 m³) inclusive	$T_{soll,\,A3} = \left(0{,}32 \log \frac{V}{m^3} - 0{,}17\right)$ s $30\ m^3 \leq V < 5000\ m^3$
A4	Lessons/communication inclusive	$T_{soll,\,A4} = \left(0{,}26 \log \frac{V}{m^3} - 0{,}14\right)$ s $30\ m^3 \leq V < 500\ m^3$
A5	Sport	$T_{soll,\,A5} = \left(0{,}75 \log \frac{V}{m^3} - 1{,}00\right)$ s $200\ m^3 \leq V < 10\,000\ m^3$ $T_{target,\,A5} = 2.0$ s $V \geq 10\,000$ s

With the implementation of the acoustic requirements and recommendations there is a differentiation made in the standard between two applications:
Rooms with an acoustic quality for medium and large distances, where in addition to a level of attenuation of the noise level in accordance with the intended purpose, there is a sufficient sound energy received by all persons present. There rooms are assigned to **group A**, see Table 2. These include:

- Classrooms
- Common rooms in kindergardens
- Conference and seminar rooms
- Auditoria
- Sports halls and indoor swimming pools

This is countered by rooms of **group B** where the highest possible reduction in noise level and limitation of the acoustical liveness are vital, see Table 3 on page 9. These include:

- Areas where people come and go and sometimes tend to remain
- Dining areas and canteens
- Exhibition halls
- Foyers
- Offices

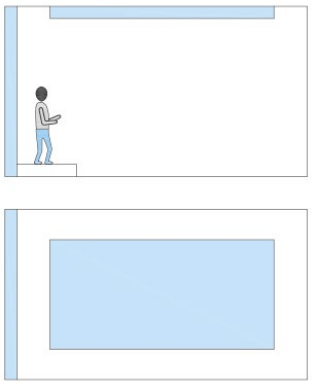
The reverberation time to be observed in group A rooms is dependent on the room volume and the mode of operation. In the DIN 18041:2016 a differentiation is made between 5 modes of operation, see Table 2 on page 6.

The range of intended spaces in dependence on the volume should not be exceeded or fallen short of in accordance with the room usage, see Table 1 on page 6. If too many persons occupy a small room not intended for the purpose, this can lead to the reverberation time being shorter than specified and the sound attenuation in the room is too high. This can have a negative effect on musical performances where the reverberation time should not be shorter than specified resulting in the sound impression being off. In this case verbal presentations may require the use of electrical amplification equipment. If on the other hand there are too few persons in a room that has been configured for verbal presentations, it is possible that the desired reverberation time is exceeded and thus there is a poor intelligibility of voices. Accordingly, determined volume indices should be targeted to suit the different main purposes of usage.

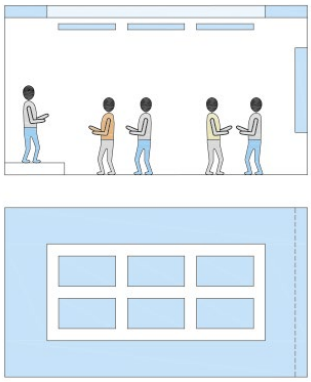
In addition to observing the target reverberation times and the consideration of the volume indices, correct positioning and distribution of the sound absorbing and reflecting surfaces is required, see images. In principle, sound absorbing materials should be distributed as equally as possible within the room. In order to avoid multiple sound reflection interference caused by walls parallel to one another, in rooms smaller than about 250 m³ the walls surface opposite the speaker should be configured to be at least partly absorbing.
Disturbing echoes occur with a time difference between arrival of the direct sound and the first sound reflection of 50 ms, which corresponds to a track distance of 17 m. Accordingly, when planning larger rooms, it is important to observe that the track distance between the direct sound and the reflections is not exceeded by correct positioning of sound absorbing or sound directing surfaces, see “Consideration of the track differences between direct sound and reflection” on page 8.

Distribution of sound absorption surfaces for small to medium room sizes acc. to DIN 18041:2015

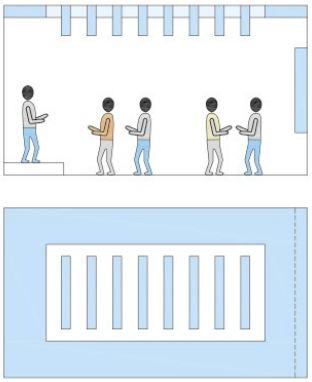
a) unfavourable



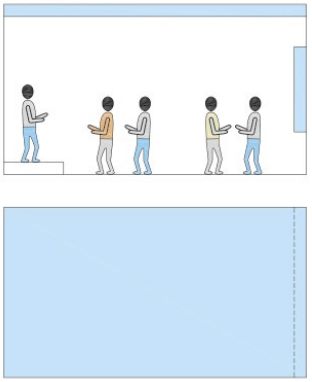
b) favourable



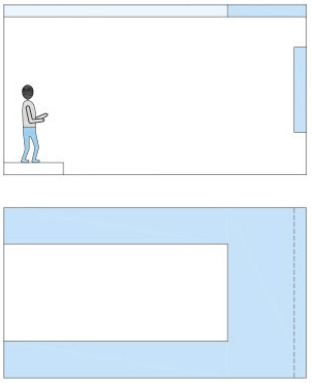
c) favourable



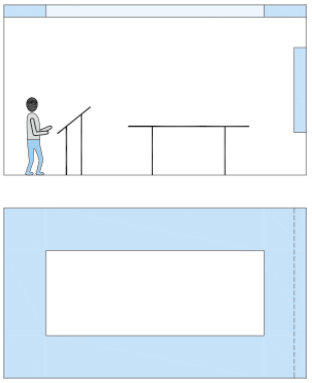
d) favourable



e) favourable



f) favourable



Furthermore, the following points must be observed:

- For larger rooms the surfaces parallel to one another should feature at least one wall surface that is partly sound absorbing, and be segmented (diffused scatter of the sound) or configured with an inclination of at least 5°.
- In order to guarantee a uniform supply of direct sound energy to all present in larger rooms, the use of targeted sound directing elements is required.
- The wall behind the speaker must be configured as acoustically hard for medium and high range frequencies.
- Circular and elliptical floor layouts must be avoided without detailed room acoustic planning.
- Concave wall and ceiling surfaces can cause problems and will require additional room acoustic measures.

Significance of the DIN 18041:2004 and DIN 18041:2016

For rooms of room group B there is also a differentiation between 5 modes of operation, whereby no requirement / recommendation is placed on the first mode of operation, see Table 3 on page 9. The orientation value for configuration of the room acoustic quality is only dependent on the room height h. The existing A/V ratio for comparison with the orientation value is either prognosis by use of a calculation method or converted using the measured reverberation time.

When forecasting the existing A/V ratio, all of the materials installed in the room are multiplied with their known sound absorption coefficients and with the size of the area that is applied. Thus the equivalent sound absorption surfaces derived for every material are added up and then set as a ratio to the volume. This A/V ratio can now be compared with the orientation values, and if necessary, further measures can be undertaken. Generally, this frequency dependence is at the octave frequencies of 250 Hz to 2000 Hz.

An alternative to the prognosis method is the measurement of the reverberation time in existing rooms. The measured reverberation times can be converted using the formula from Sabine to the equivalent sound absorption surface.

Sabine's reverberation time formula:

$T = 0.163 \cdot V/A$

T reverberation time in s.

V room volume in m³

A equivalent sound absorption surface in m²

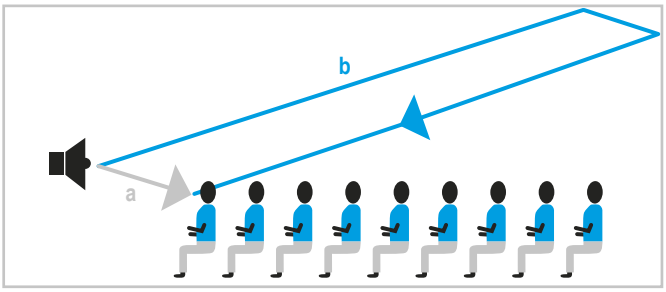
As T has been measured, the formula can be converted to result in A and indicate the A/V ratio:

$A = 0.163 \cdot V/T$

Consideration of the track differences between direct sound and reflection

unfavourable

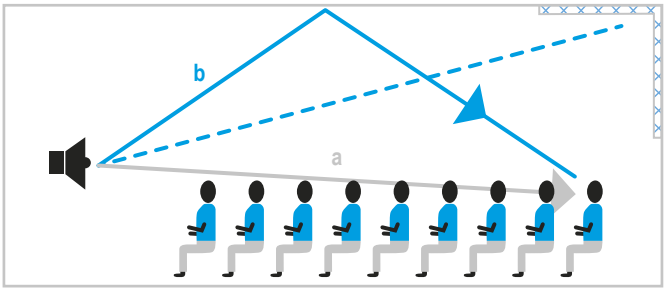
b - a ≥ 17 m



favourable

b - a < 17 m

Sound absorbed in the edge area to reduce the rear wall reflections



favourable

b - a < 17 m

Reflection surface in the edge area to direct the rear wall reflections

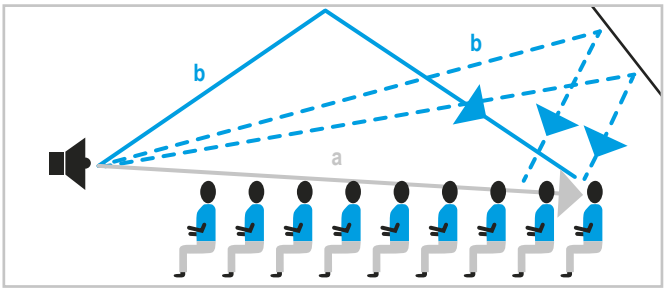


Table 3: Orientation values for the A/V ratio in dependence on the modes of operation

Room group	Mode of operation	Requirement
B1	Rooms without occupancy quality	No requirement
B2	Rooms where you briefly linger	$A/V \geq \frac{1}{4{,}8 + 4{,}69 \log\left(\frac{h}{1\,m}\right)}$
B3	Rooms where you remain for longer	$A/V \geq \frac{1}{3{,}13 + 4{,}69 \log\left(\frac{h}{1\,m}\right)}$
B4	Rooms with requirement for noise reduction and room comfort	$A/V \geq \frac{1}{2{,}13 + 4{,}69 \log\left(\frac{h}{1\,m}\right)}$
B5	Rooms with special requirement for noise reduction and room comfort	$A/V \geq \frac{1}{1{,}47 + 4{,}69 \log\left(\frac{h}{1\,m}\right)}$

Definitions of the sound absorption coefficients following EN ISO 11654

The building materials and substances used in a room can be sound reflective from an acoustical point of view, so that they have no or very low sound absorbing characteristics. In this case the rated sound absorption coefficient α_w is practically 0.

In contrast, there are materials that are highly sound absorbing. Should 100% of the impinging sound energy be absorbed, i.e. the sound energy is fully converted to heat energy, the rated sound absorption coefficient α_w is practically 1.

α_s indicates the values of the frequency-dependent sound absorption coefficient measured in a reverberation chamber in third octaves. The practical sound absorption coefficient is formed based on this factor.

α_p are the values of the frequency-dependent, practical sound absorption coefficient made up of three third octaves. They are frequently used for frequency-dependent prognoses.

α_w is the rated sound absorption coefficient. It is independent of the frequency and specified as a single value quantity. The determination of the single value quantity is undertaken in accordance with the procedure described on page Page 10.

Shape indicators as suffixes to the rated sound absorption coefficient provide some indication of whether an absorbing material is particularly effective in the low, medium or high frequency range.

The following indicators are used:

- **L**, when the product is particularly effective in the low frequency range e.g. $\alpha_w = 0.60$ (L)
- **M**, when the product is particularly effective in the medium frequency range. e.g. $\alpha_w = 0.70$ (M)
- **H**, when the product is particularly effective in the high frequency range. e.g. $\alpha_w = 0.85$ (H)

Combinations are possible.

e.g. $\alpha_w = 0.70$ (MH)

Sound absorption class and descriptive term acc. to VDI 3755

Weighted sound absorption coefficient α_w:	Rating
≥ 0.80	Extremely absorbing
0.60 – 0.75	Highly absorbing
0.30 – 0.55	Absorbing
0.15 – 0.25	Hardly absorbing
≤ 0.10	Reflecting

Sound absorption coefficients following EN ISO 11654

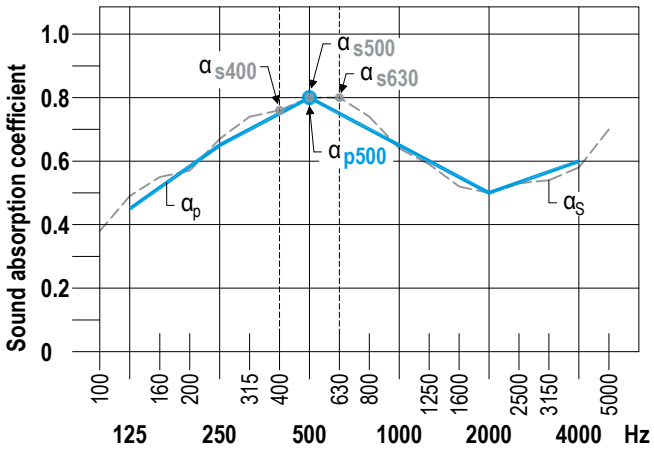
Determination of the single value quantity of the sound absorption coefficient α_w

1) Sound absorption coefficient

α_S = **Sound absorption coefficient for third octave bandwidth**
frequency-dependent value of sound absorption coefficient
acc. to DIN EN ISO 354, measured in third octave bands

α_p = **Practical sound absorption coefficient**
from α_S on octave bands converted
acc. to DIN EN ISO 11654

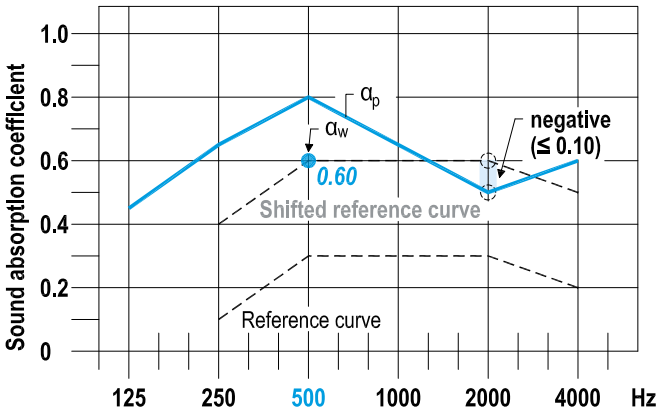
Example for 500 Hz: $\alpha_p 500 = \frac{\alpha_S 400 + \alpha_S 500 + \alpha_S 630}{3}$



2) Weighted sound absorption coefficient

α_w = **Weighted sound absorption coefficient**
acc to DIN EN ISO 11654
Single number parameter of sound absorption coefficient
determined from a shifted reference curve
(sum of all negative deviations ≤ 0.10) and the
point of intersection at **500 Hz** acc. to DIN EN ISO 11654

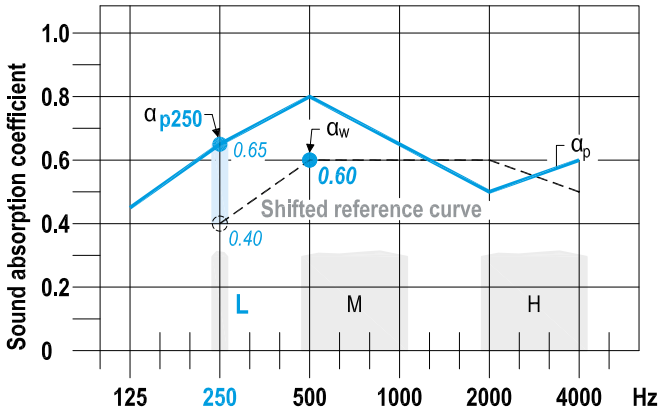
Example:



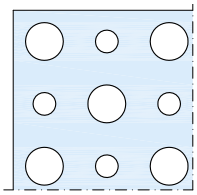
3) Shape indicators

α_w with shape indicators = α_w (...)
if α_p exceeds the reference curve for a single octave frequency by **≥ 0.25**
then add:
(L) at 250 Hz **(M)** at 500 or 1000 Hz **(H)** at 2000 or 4000 Hz

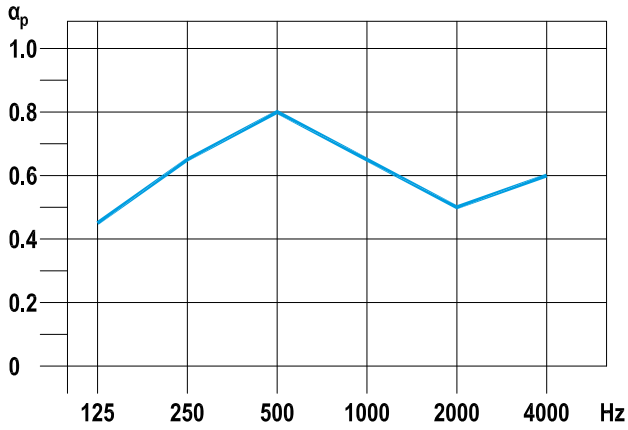
Example (250 Hz): 0.65 - 0.40 = 0.25 (≥ 0.25) = (L) → α_w = 0.60 (L)



Example



Alternating circular perforation 12/20/66 R
with acoustical fleece
Perforation ratio: 19.6 %



Construction depth 200 mm

α_p	0.45	0.65	0.80	0.65	0.50	0.60

α_w **= 0.60 (L)** Highly absorbing

Concepts

Rooms of group A

Rooms of group B

On the following pages you will find sample configurations for different rooms and modes of operation. The materials selected for the perimeter surfaces as well as the dimensions correspond partly with designs found in practice, partly with realistic assumptions. The sample configurations are intended to highlight the necessity for room acoustic measures and offer support in the planing and design of these rooms. As described in the Basics chapter, the determination of the requirements for differentiation between rooms classified as group A and group B is described. For rooms of group A there is a further division between the configuration with and without inclusion.

The forecasting of the reverberation time is undertaking according to the statistical reverberation theory. The position of absorbing materials is not considered with this method. In fact, a diffused sound field is assumed. This approach is adequate for small to medium size rooms with sufficient diffusion, induced by the furnishings or other equipment. For large rooms or halls it cannot be generally assumed that a diffused sound field exists. With this knowledge and in the first approximation, the statistical reverberation theory is still applied to forecast the reverberation time in the following.

Fundamentals

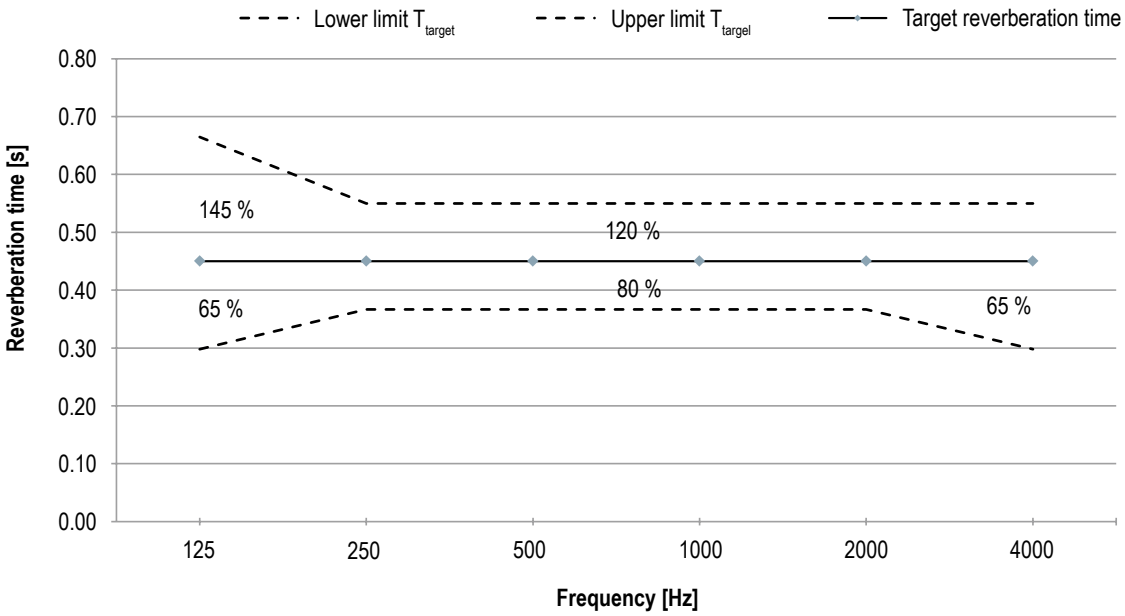
The target reverberation time to be calculated provides a target value for medium-range frequencies (500 Hz and 1000 Hz). As a design of the room acoustic quality to exactly meet these target values is not always possible, and significant, frequency-dependent exceeding or falling short of the requirements is to be avoided, the rooms of room group A1 to A4 are provided with a tolerance range in which the frequency-dependent reverberation times must be found.

For room group A5 (sports halls and indoor swimming pools) the target reverberation time for frequencies 250 Hz to 2000 Hz must be complied with to an accuracy of ± 20 %. If a room cannot be explicitly categorized to a room group because of its usages, a weighted average value in accordance with the main area of use must be determined.

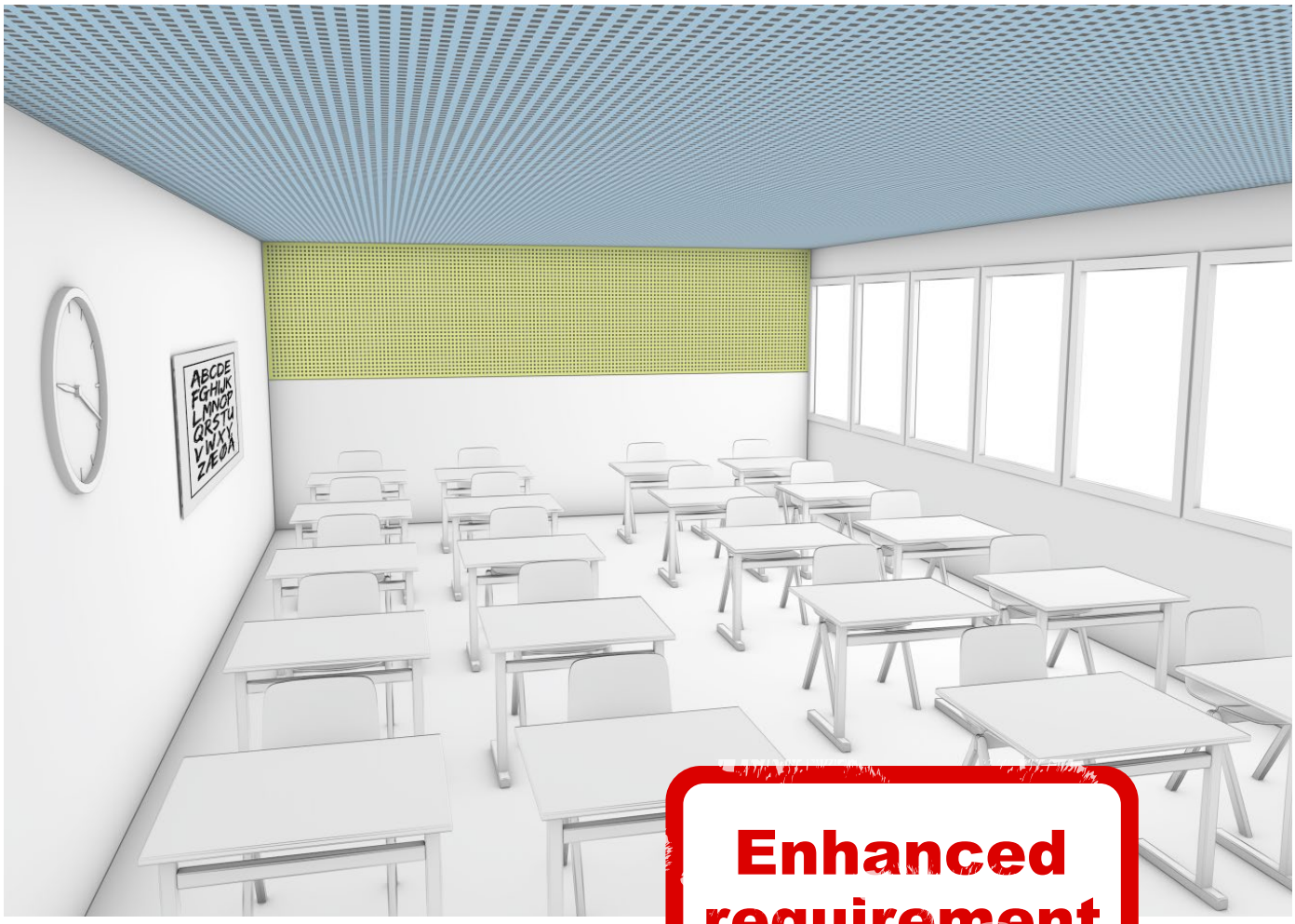
The defined requirements always relate to the occupied and furnished condition. This must be considered when designing the room. Generally, an occupancy of 80 % is to be assumed in the prognosis calculations. If a lower occupancy is to be expected due to the room usage, the room should be configured for 80 % of the occupancy rate and compensation measures should be undertaken. Compensation measures of this kind can be sound absorbing seating, if the seating is not occupied, or mobile absorption surfaces in the form of acoustically effective curtains placed before acoustically hard wall surfaces that can be opened, partly opened or remain closed to suit the level of room occupancy.

The DIN 18041:2016 differentiates between a room usage with and without enhanced requirements (with and without inclusion). The defined requirements in a target reverberation time with inclusion takes consideration of the necessity of an improved room acoustic quality for persons with hearing impairments, attention and language deficits as well as for communication in a language that is not a native tongue. New buildings in particular, should always take the enhanced requirements into consideration during the planning and application phases.

Examples of the tolerance ranges for the main purpose of usage of communication and a target reverberation time of 0.45 s



Classroom with inclusion



Concept for classroom with inclusion

In small rooms up to about 250 m³ there is hardly any danger of excessive attenuation. In fact the enhanced level of attenuation and the accompanying significant reduction of the noise level favours this. An implementation of room acoustic measures accommodates active lessons as it can significantly reduce the verbal presentation effort for the teacher and makes communication with the students significantly more relaxed. Thus any unrest in the classroom due to the room acoustic quality is reduced enhancing the discipline and the ability of the students to concentrate.

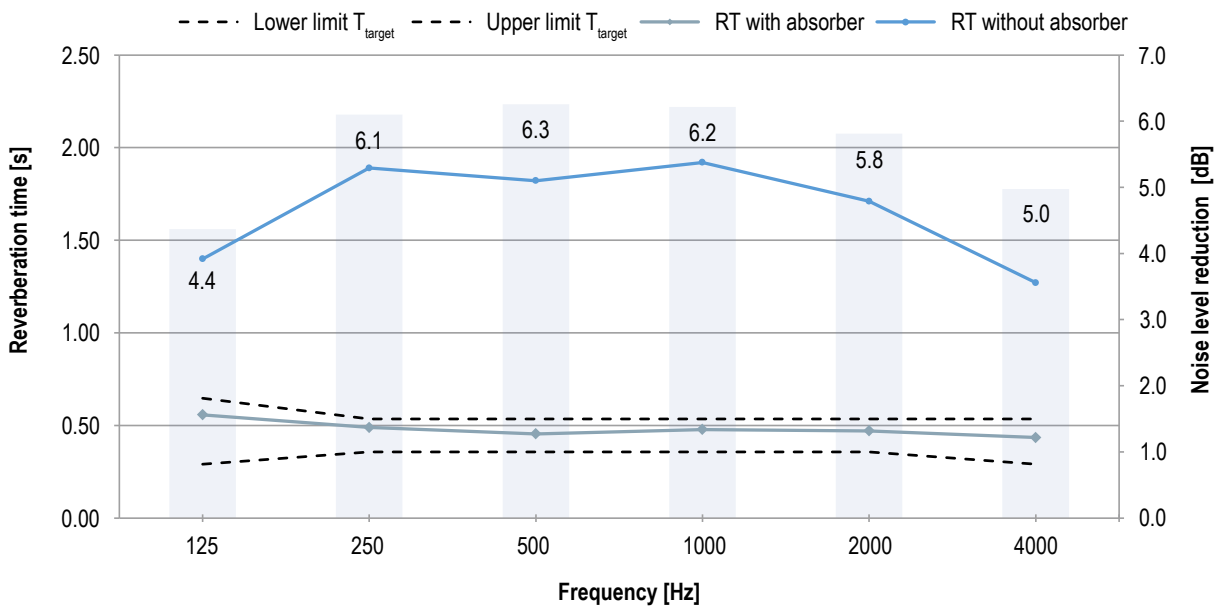
Input data for room acoustic prognosis

Room geometry

■ Length	10 m
■ Width	6 m
■ Height	3 m
■ Volume	180 m³

Materials used

■ Exterior wall	Plastered masonry with ribbon windows
■ Corridor wall	Lightweight partition
■ Partitions	Lightweight partition
■ Floor covering	Linoleum
■ Ceiling	Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 20 students, without absorber	T = 1.67 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.36 – 0.54 s
Forecast reverberation time	T = 0.47 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	5 – 6 dB

The requirement is met by the application of the following systems or products

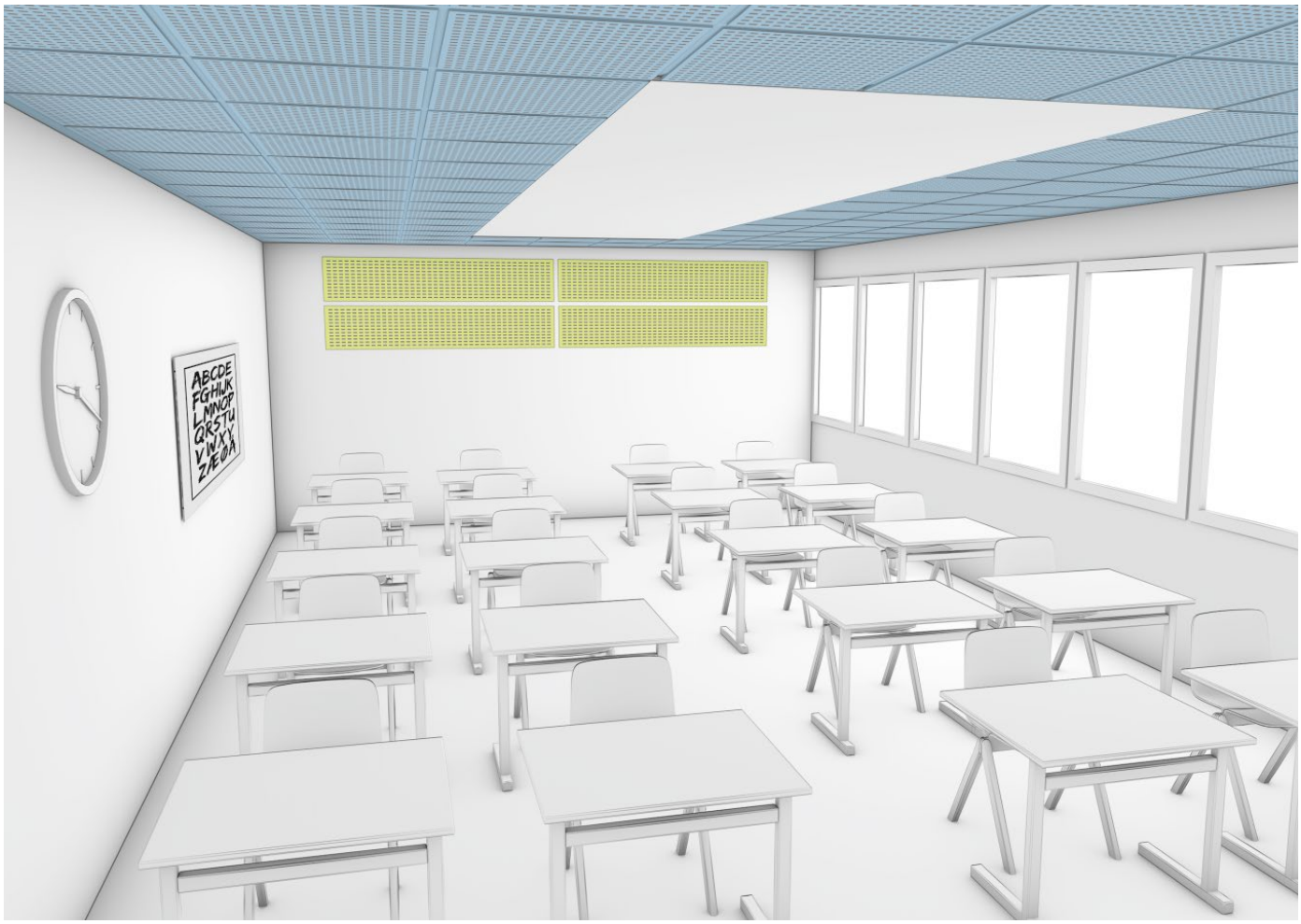
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Standard square perforation 12/25 Q	Construction depth 200 mm	Full surface
Wall absorber	W112C.de Cleaneo Acoustic Wall Perforation pattern: Standard square perforation 12/25 Q	Wall thickness 132.5 mm	Share of the surface Cleaneo acoustic boards 50 %

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber (e.g. Belgravia, perforation pattern: Unity 3)	≥ 0.70
Wall absorber (e.g. Adit)	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Classroom without inclusion



Concept for classroom without inclusion

Input data for room acoustic prognosis

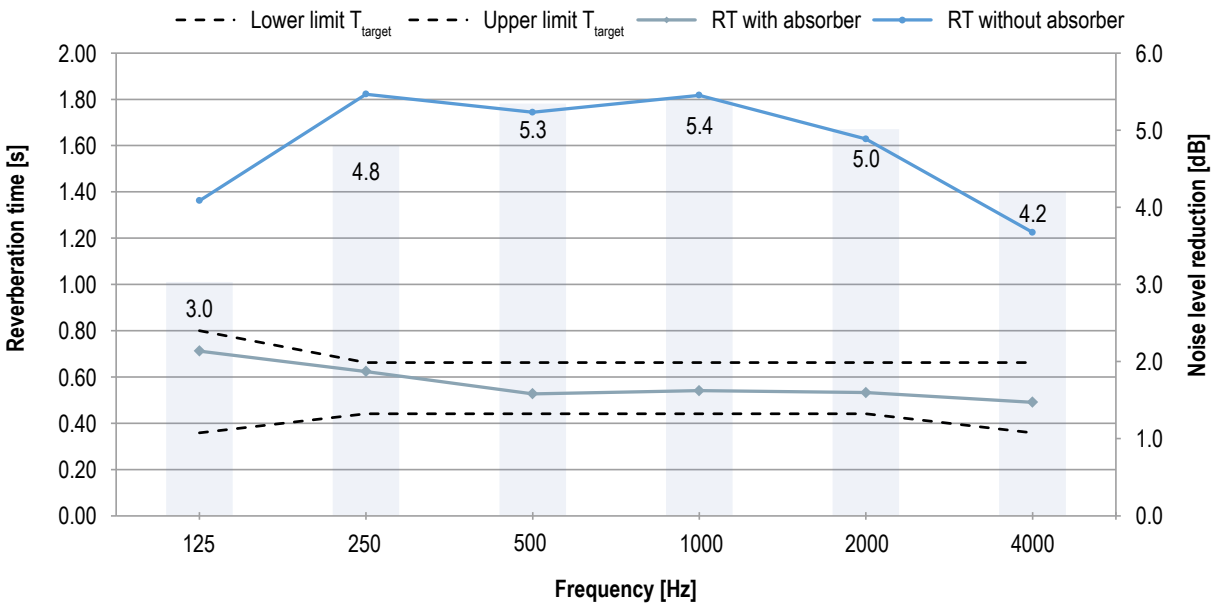
Room geometry

- Length 10 m
- Width 6 m
- Height 3 m
- Volume 180 m³

Materials used

- Exterior wall Plastered masonry with ribbon windows
- Corridor wall Lightweight partition
- Partitions Lightweight partition
- Floor covering Linoleum

■ Ceiling Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 20 students, without absorber	T = 1.67 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.44 – 0.66 s
Forecast reverberation time	T = 0.56 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	4 – 5 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D145.de Acoustical Dropped Ceiling Belgravia Perforation pattern: Tangent	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	Wall absorber Adit	–	1/3 of the rear wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber (e.g. Cleaneo Acoustic Board Ceiling perforation pattern: 8/18 R with acoustical fleece)	≥ 0.60
Wall absorber (e.g. Cleaneo Acoustic Wall 1/3 perforated, perforation pattern: 8/18 R)	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Kindergarden common room with inclusion

Concept for kindergardens with inclusion

Noise is one of the main sources of stress for preschool teaching staff as well as for children in kindergardens and daycare facilities. A high level of noise not only can cause aural damage (damage to hearing), it can also have effects on the cardiovascular system, on the human psyche and thus be accompanied by elevated stress phenomena (so-called extra-auditory damage). Children in particular are susceptible due to their not yet fully developed mental and physical state and have even greater problems with concentration and learning ability when subjected to noise.

As is the case with classrooms, the DIN 18041:2016 differentiates in the definition of the requirements between common rooms in kindergardens with and without inclusion. As it is not possible to assume that only children with exclusively perfect hearing and without concentration difficulties or children with the same native tongue will be attending the kindergarden, inclusion should always be included in the planning and implementation phase with new buildings.

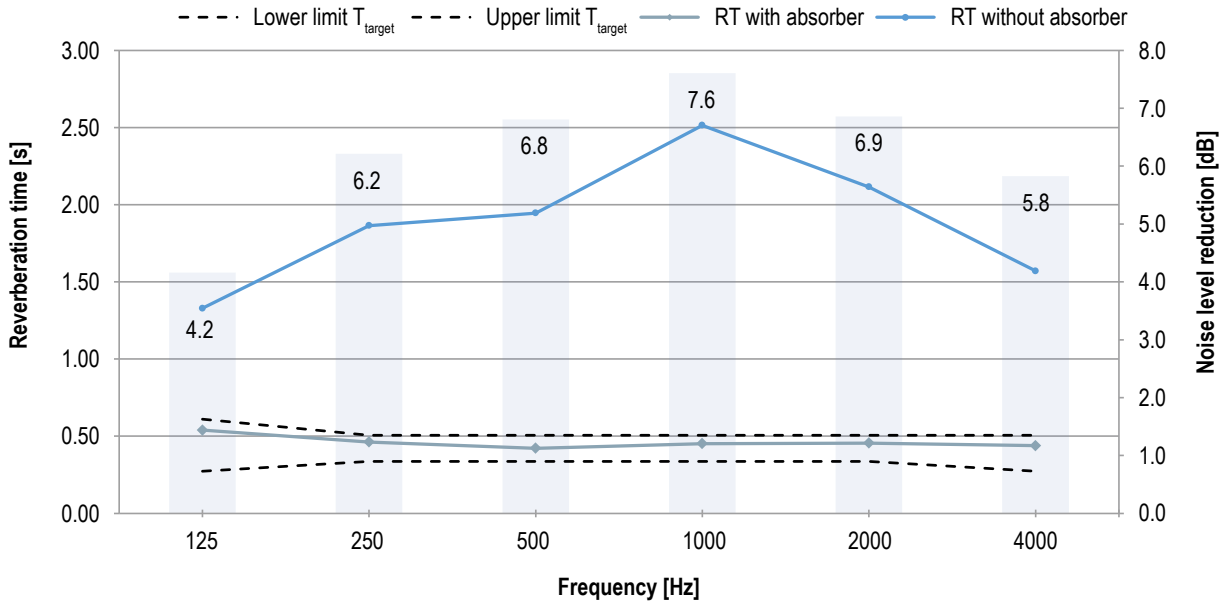
Input data for room acoustic prognosis

Room geometry

■ Length	8 m
■ Width	6 m
■ Height	3 m
■ Volume	144 m³

Materials used

■ Exterior wall	Plastered masonry with ribbon windows
■ Corridor wall	Lightweight partition
■ Partitions	Lightweight partition
■ Floor covering	Linoleum
■ Ceiling	Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 10 students, without absorber	T = 1.92 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.34 – 0.51 s
Forecast reverberation time with absorber	T = 0.45 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	6 – 7 dB

The existing reverberation time may vary in dependence on the furnishings such as carpets, curtains, open book cases, couch upholstery, etc.

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Square perforation 12/25 Q	Construction depth 200 mm	Full surface
Wall absorber	Wall absorber Adit	–	About 1/3 of a wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.80
Wall absorber	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Kindergarden common room without inclusion

Concept for kindergardens without inclusion

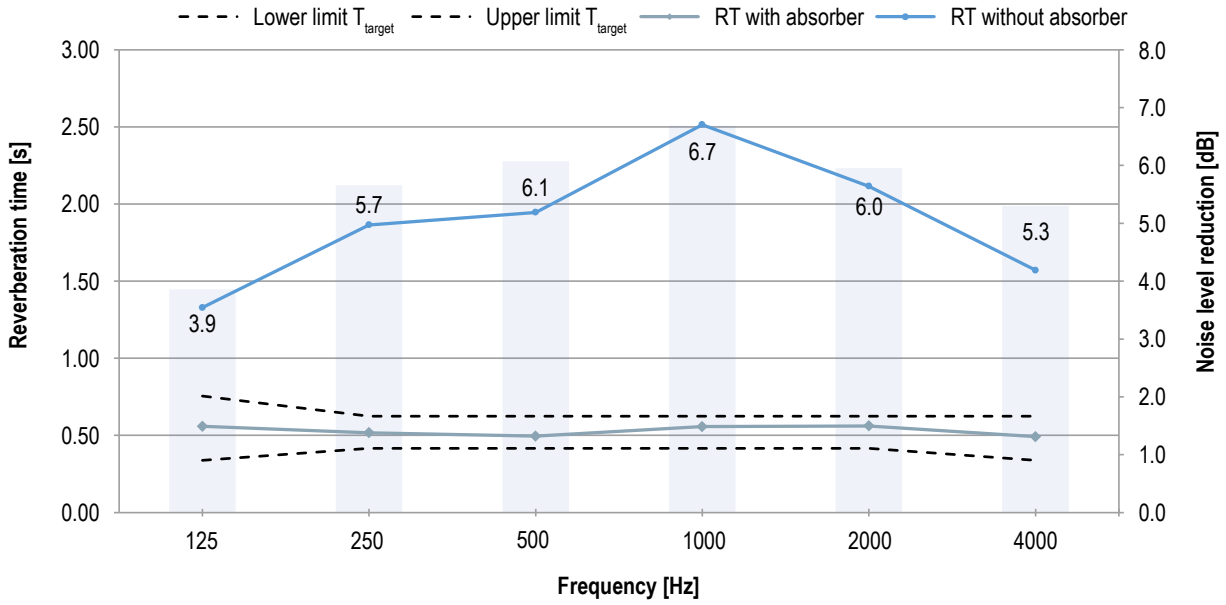
Input data for room acoustic prognosis

Room geometry

- Length 8 m
- Width 6 m
- Height 3 m
- Volume 144 m³

Materials used

- Exterior wall Plastered masonry with ribbon windows
- Corridor wall Lightweight partition
- Partitions Lightweight partition
- Floor covering Linoleum
- Ceiling Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 10 students, without absorber	T = 1.92 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.42 – 0.62 s
Forecast reverberation time with absorber	T = 0.53 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	5 – 6 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Square perforation 12/25 Q	Construction depth 200 mm	Full surface

A better room acoustic quality can be achieved when the absorber surfaces are distributed on the ceilings and walls, e.g.

- 2/3 of the ceiling surface acoustically effective, e.g. Cleaneo Acoustic board ceilings 8/18 R with acoustical fleece in combination with
- 2x 10 m² Designpanel T3L1 on the walls

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.75

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Music rehearsal room with active music making and singing

Concept for music rehearsal room with active music making and singing

Sweeping statements on the correct design of music rooms irrespective of the instruments used or the type of singing are almost impossible to make. According to E DIN 18041:2015 longer reverberation times in rehearsal rooms for young musical students, e.g. when singing or playing the recorder, increase the musical pleasure. On the other hand, brass or stringed instruments as well as percussion instruments favour shorter reverberation times.

The following design is therefore limited to the requirements of a target reverberation time analogue to room group A1 for music rehearsal room with active music making and singing in educational institutions.

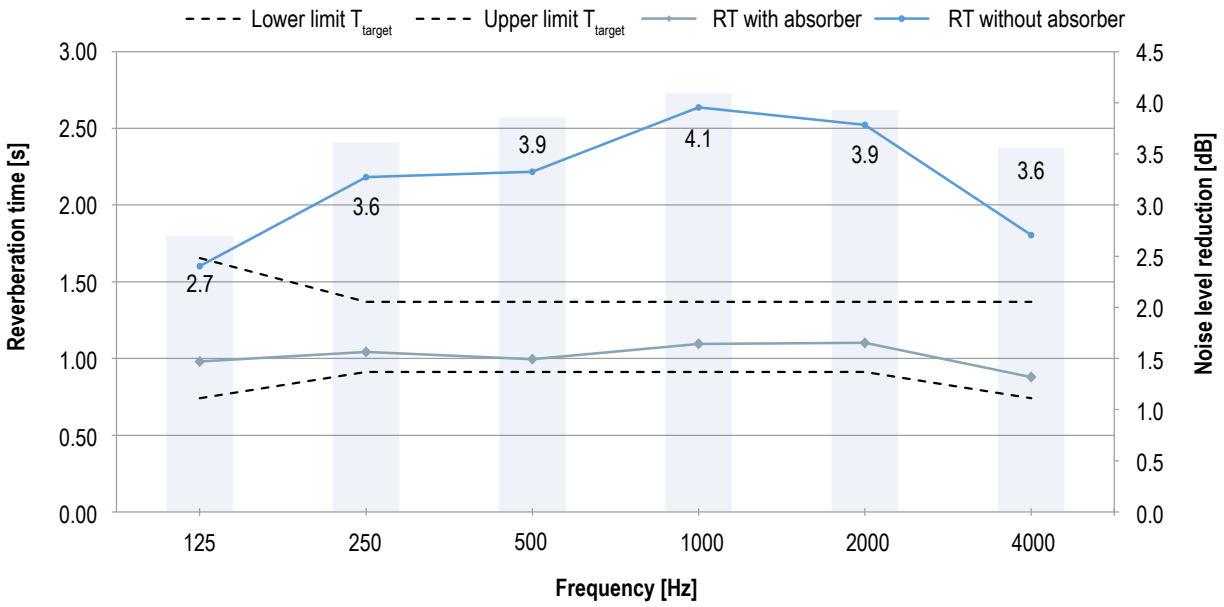
Input data for room acoustic prognosis

Room geometry

- Length 10 m
- Width 8 m
- Height 3 m
- Volume 240 m³

Materials used

- Exterior wall Plastered masonry with ribbon windows
- Corridor wall Lightweight partition
- Partitions Lightweight partition
- Floor covering Parquet
- Ceiling Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 15 musicians/singers, without absorber	T = 1.92 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.91 – 1.37 s
Forecast reverberation time with absorber	T = 1.06 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings Perforation pattern: Circular perforation 6/18 R	Construction depth 200 mm	50 % of the ceiling surface
Wall absorber	W112C.de Cleaneo Acoustic Wall Perforation pattern: Circular perforation 8/18 R	Wall thickness 132.5 mm	Share of the surface Cleaneo Acoustic Boards 50 %

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.45
Wall absorber	≥ 0.75

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

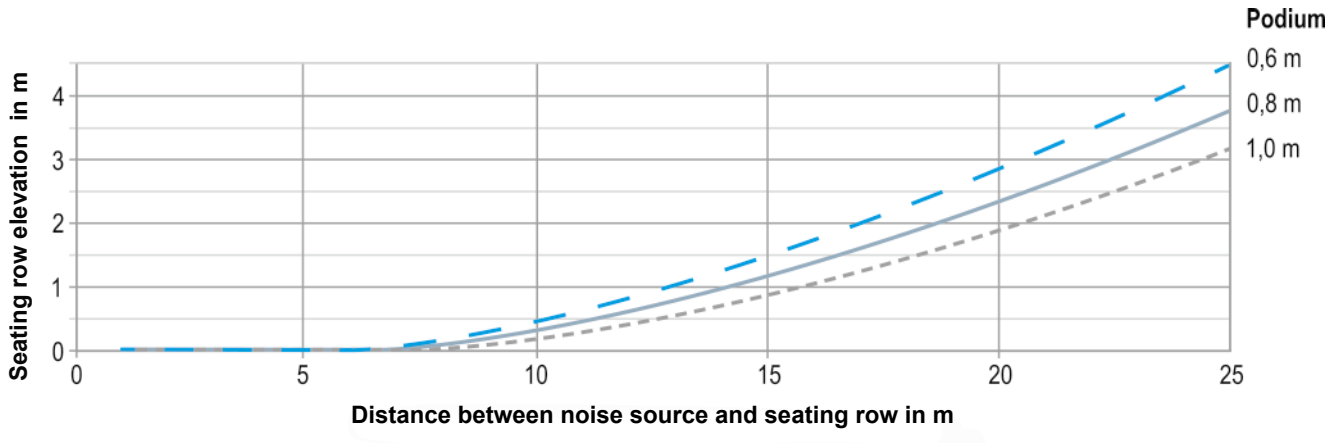
Auditoria

Further parameters must be considered to ensure good intelligibility of voices in addition to the requirements for target reverberation times based on the room dimensions of typical auditoria. For verbal presentations it is important to ensure that a volume index if 4 to 6 m³/seat is observed. With wall surfaces that are parallel to one another one wall surface should be at least partly sound absorbing. Alternatively, the configuration of a wall surface with large format segments that can be used for targeted directing of sound is possible.

If a inclined positioning of the wall is to be provided to avoid the disruptive sound reflections, the inclination should be at least 5°.

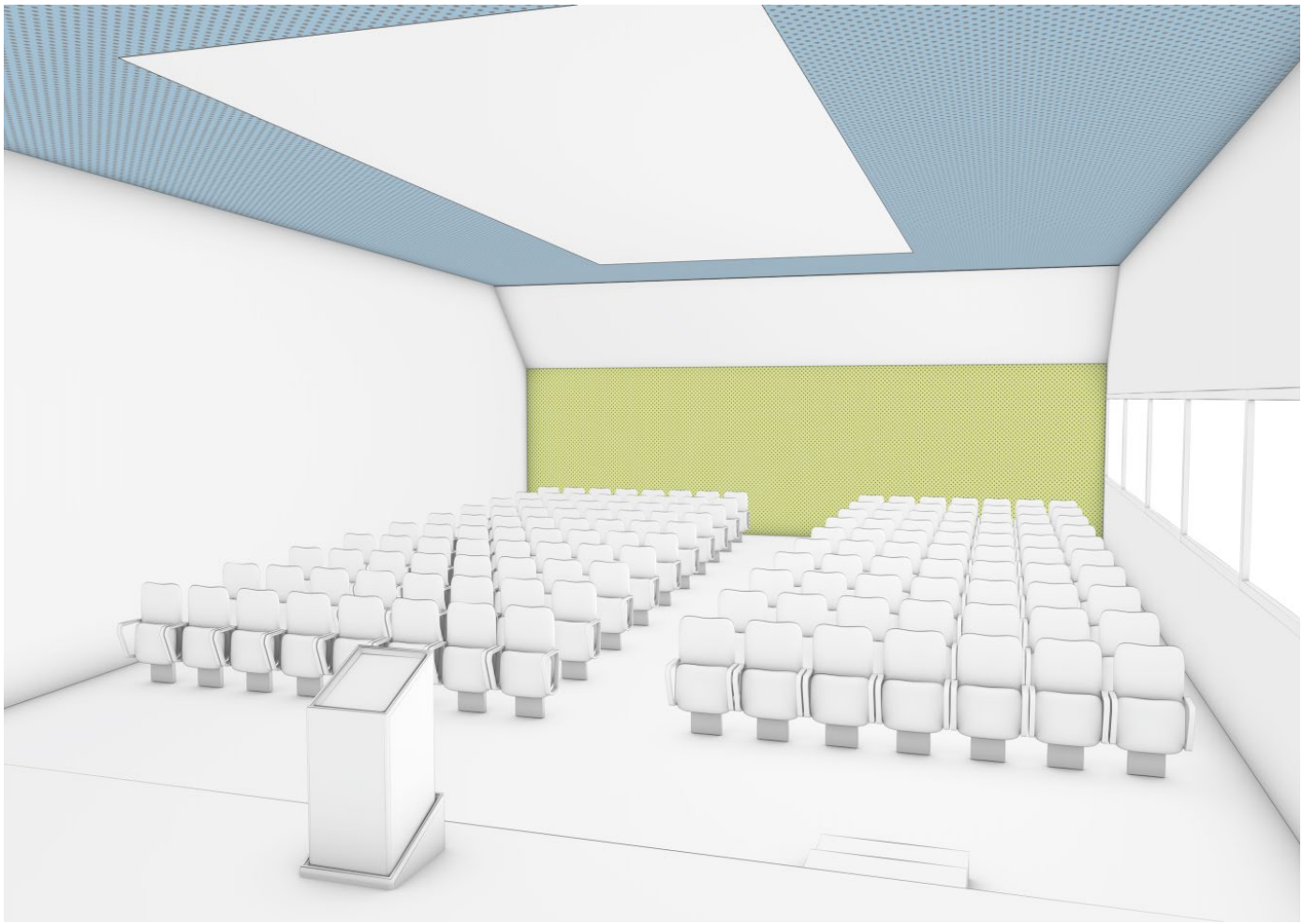
In order to evenly distribute the direct sound from the speaker as evenly as possible, large format, acoustically hard ceiling canopies at an inclined angle can be positioned over the speaker's podium ensuring that the sound is directed to the rear area of the room. Elevated seating rows are a very useful measure to improve the audibility and line of sight with more than about 10 seating rows. The necessary seating row elevation as a function of the distance of the audience and the podium height can be seen in the following figure.

Furthermore, with sound absorbing and/or sound directing measures sound path differences ≥ 17 m between the sound source to the recipient and the sound source, reflection and recipient are to be avoided.



Additional measures particularly with soft-spoken speakers and / or a large number of listeners may require the use of electrical amplification equipment.

Auditoria without elevated seating rows



Concept for auditoria without elevated seating rows

Auditoria without elevated seating rows should not exceed a maximum of 10 rows of seats to ensure audibility and line of sight.

Based on the volume index the seating in the room can be for 150 to 225 persons.

Furthermore, a slanted ceiling or ceiling canopy at an inclined angle of between 15° to 25° should be provided above the speaker's podium to direct sound into the area of the listeners.

To avoid disruptive rear wall sound reflections the wall surface opposite the speaker will require an acoustically effective design.

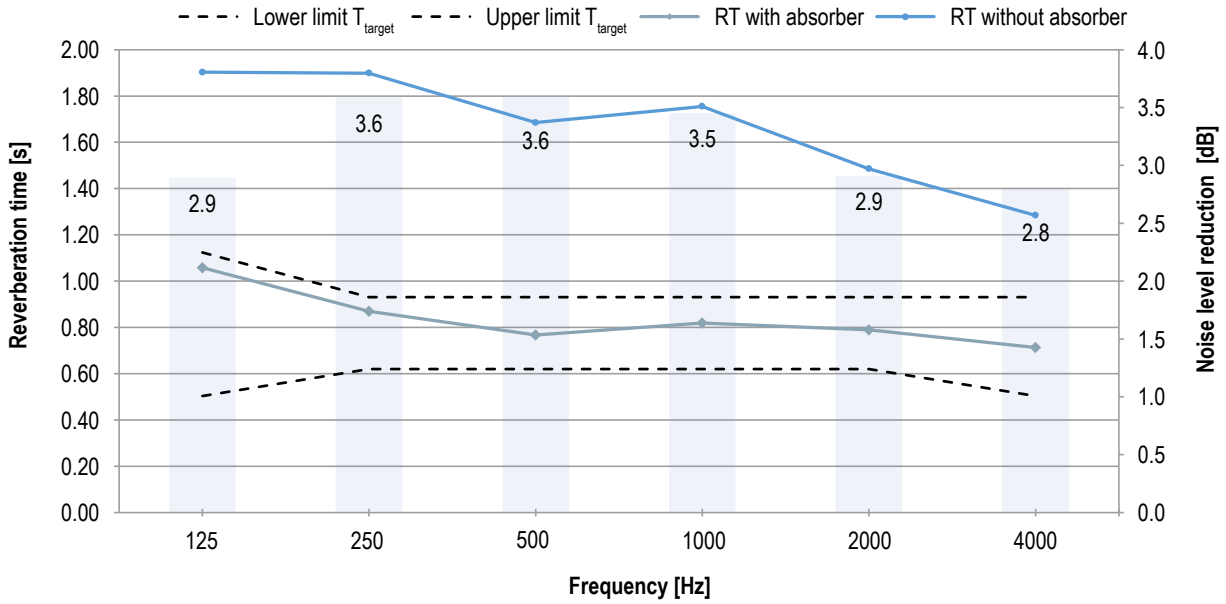
Input data for room acoustic prognosis

Room geometry

■ Length	18 m
■ Width	10 m
■ Height	5 m
■ Volume	900 m³

Materials used

■ Exterior wall	Plastered masonry with ribbon windows
■ Partitions	Lightweight partition
■ Floor covering	Parquet
■ Ceiling	Suspended ceiling with gypsum board cladding (unperforated)



Room acoustical data	
Forecast reverberation time including 120 (80 %) persons, without absorber	T = 1.55 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.62 – 0.93 s
Forecast reverberation time with absorber	T = 0.81 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

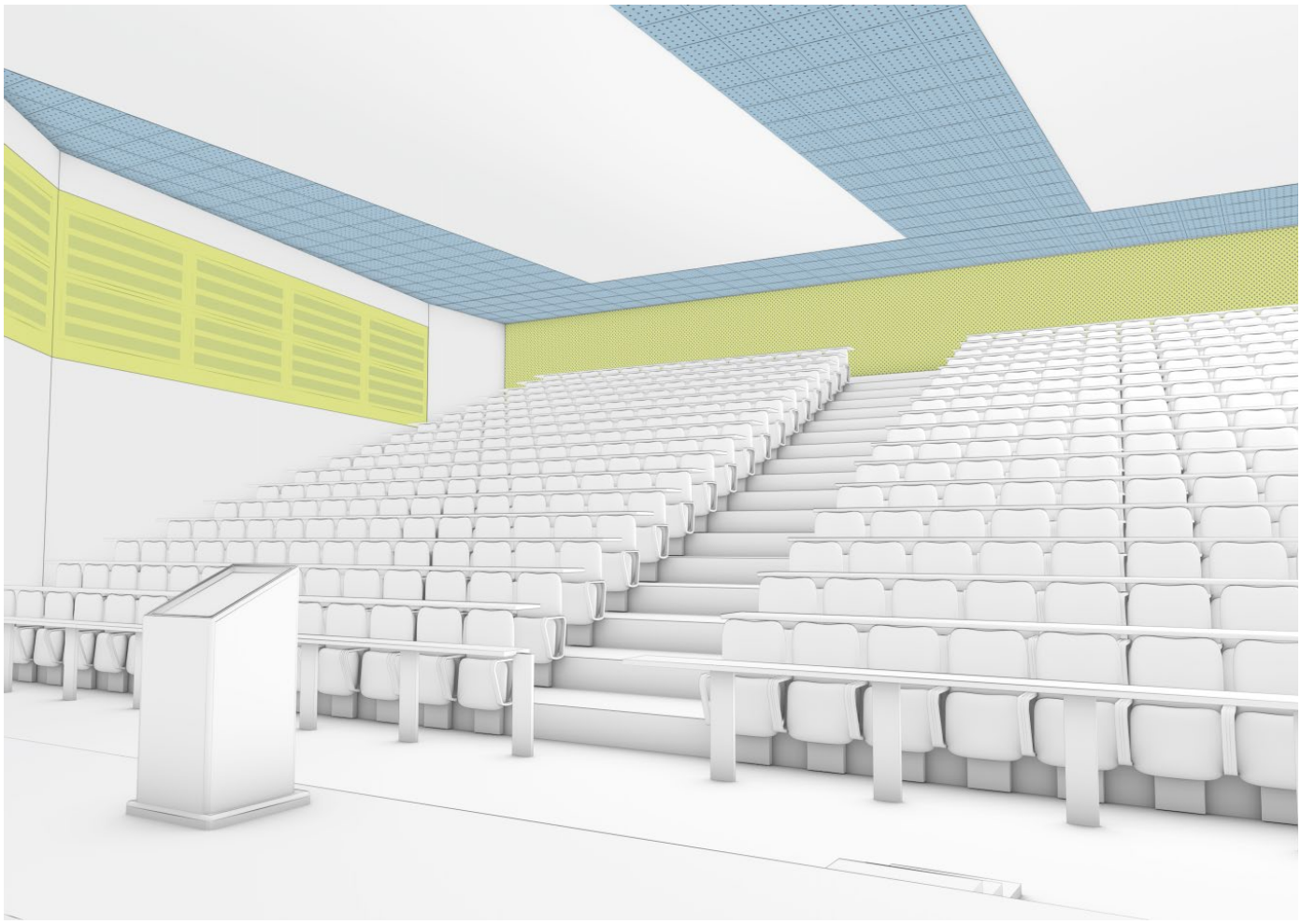
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings Perforation pattern: Circular perforation 10/23 R	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	Wall lining W623C.de Furring Cleaneo Acoustic Boards with CD 60/27 Perforation pattern: Circular perforation 8/18 R	Share of the surface Cleaneo Acoustic Boards 100 % Construction depth 112.5 mm	Rear wall full surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.60
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Auditoria with elevated seating rows



Concept for auditoria with elevated seating rows

Elevated row seating is intended for sufficient audibility and line of sight.

Based on the volume index the seating in the room can be for 365 to 550 persons.

The cubage of the room should be selected so that disruptive reflections are avoided and as much direct sound as possible should be directed into the area of the listeners. Electrical amplification equipment should be used with rooms of this size with so many people.

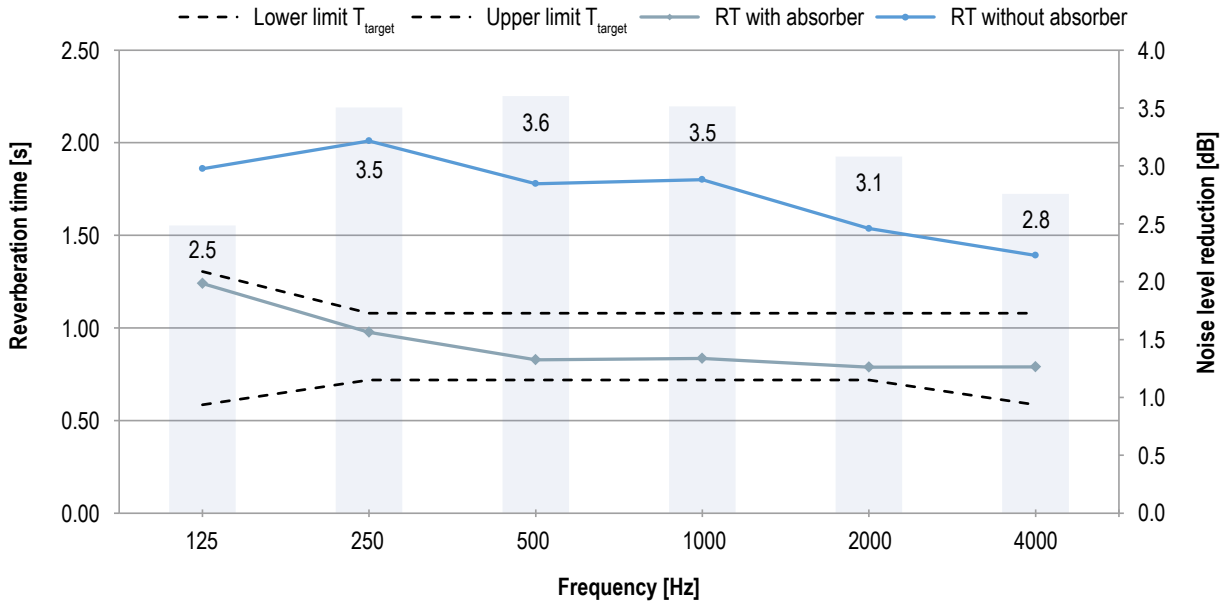
Input data for room acoustic prognosis

Volume

2200 m³

Materials used

■ Partitions	Concrete walls
■ Floor covering	Parquet
■ Ceiling	Suspended ceiling with gypsum board cladding (unperforated)



Room acoustical data	
Forecast reverberation time including 290 (80 %) persons, without absorber	T = 1.73 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.72 – 1.08 s
Forecast reverberation time with absorber	T = 0.86 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

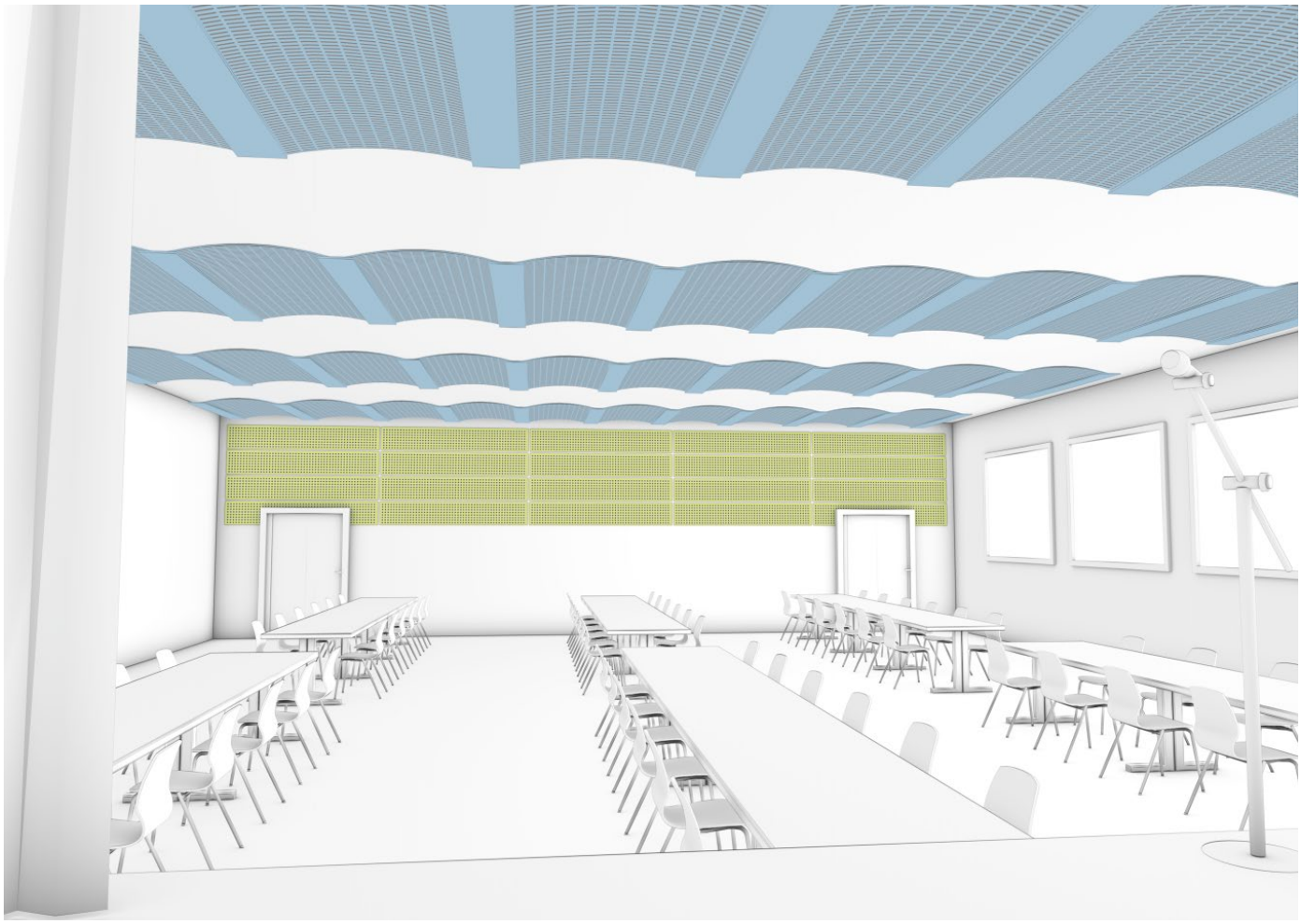
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D147.de Cleaneo Acoustical Dropped Ceiling Contur Perforation pattern: Micro	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	W623D.de Cleaneo Acoustic Wall Lining Designpanel Perforation pattern: Tangent T3L1	Share of the surface Designpanel 100 % Construction depth 77.5 mm	Rear wall full surface
Wall absorber	W623D.de Cleaneo Acoustic Wall Lining Designpanel Perforation pattern: Tangent T3L1	Share of the surface Designpanel 33 % Construction depth 77.5 mm	1/3 of the side walls surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.65
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Community or meeting hall



Concept for community or meeting hall

Community and meeting halls often have diverse uses. These include, for example, club meetings and celebrations, musical rehearsals and musical recitals or for use as seminar or lecture areas. Accordingly, the design of the room acoustic quality must be focused on the main intended usage purpose (verbal or musical presentations). Alternatively, you can work with mobile absorber elements that can be optimally tuned to suit practically every room usage. However, in practice, these kinds of elements are usually unacceptable or not used in these types of rooms and mobile absorber elements usually only function in the theoretical prognosis. Accordingly, the following sample design concept is configured for a room acoustics point of view so that it is possible that verbal presentations of individual speakers achieve good intelligibility of voices as well as good conditions for musical rehearsals. However this compromise solution must take into account that musical performances will generally be perceived by the audience as too vibrant. This means the reverberation time in the room is too short for the most performances with instruments or singing.

Input data for room acoustic prognosis

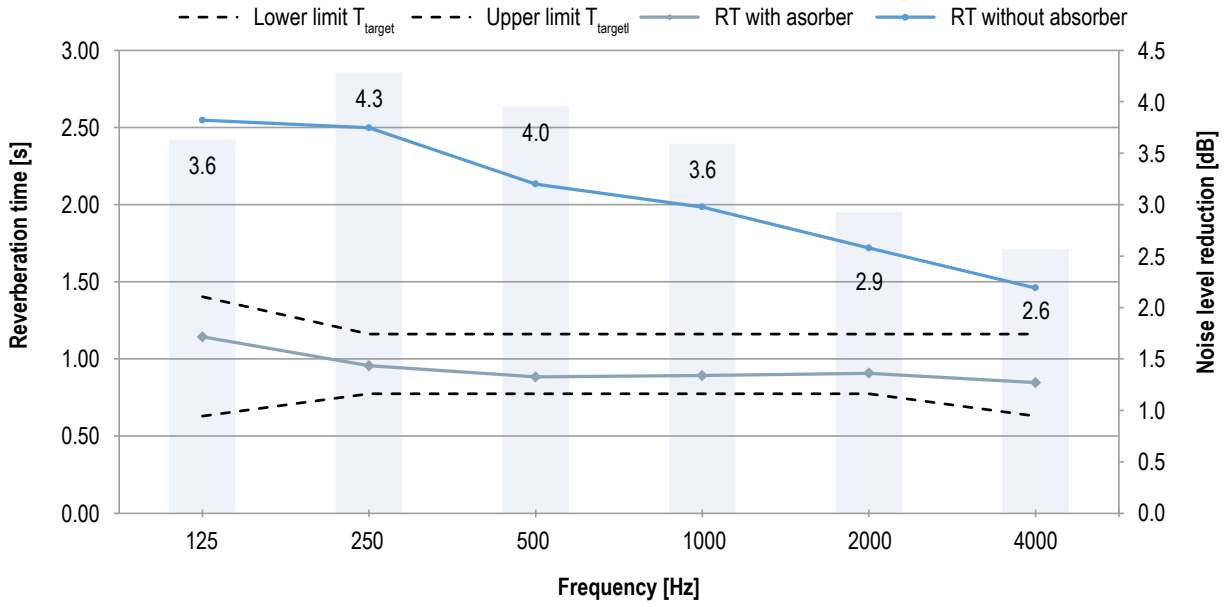
Room geometry

- Length 20 m
- Width 13 m
- Height 3.8 m
- Volume 988 m³

Including a stage on the front side

Materials used

- Exterior wall: Plastered masonry with ribbon windows
- Front wall 1: Plastered masonry with wooden cladding
- Front wall 2: Plastered masonry
  Curtain closed in the stage area
- Corridor wall: Lightweight partition
- Floor covering: Parquet
- Ceiling: Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 50 persons, without absorber	T = 2.06 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.77 – 1.16 s
Forecast reverberation time with absorber	T = 0.91 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Slotline B6	Construction depth 200 mm	50 % of the ceiling surface
Wall absorber	W629C.de Wall Lining Furring Cleaneo Acoustic Boards with CW double profiles Perforation pattern: Square perforation 12/25 Q	Share of the surface Cleaneo Acoustic Boards 50 % Construction depth 112.5 mm	50 % of the surface of the wall opposite the stage

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.65
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Conference rooms with inclusion

Concept for conference rooms with inclusion

Spending several hours in a conference, seminar or meeting room is not in any way unique. Frequent difficulties encountered are exhaustion, tiredness and loss of receptiveness for new information. This may also be due to the discussions that often have far reaching consequences. However, these symptoms are often additionally reinforced by poor room acoustics. Without acoustic measures the noise level can ramp up quickly in enclosed rooms due to the loudness of the speaker and the levels of sound reflection. This quickly leads to an enormous physical strain and additional effort as well as to the reduction in the intelligibility of words, sentences and syllables, required additional effort from the human brain in order to follow the conversation. This effect is reinforced yet again when the communication with the other participants is not in your native tongue and/or the participant has hearing difficulties for reasons or health or age.

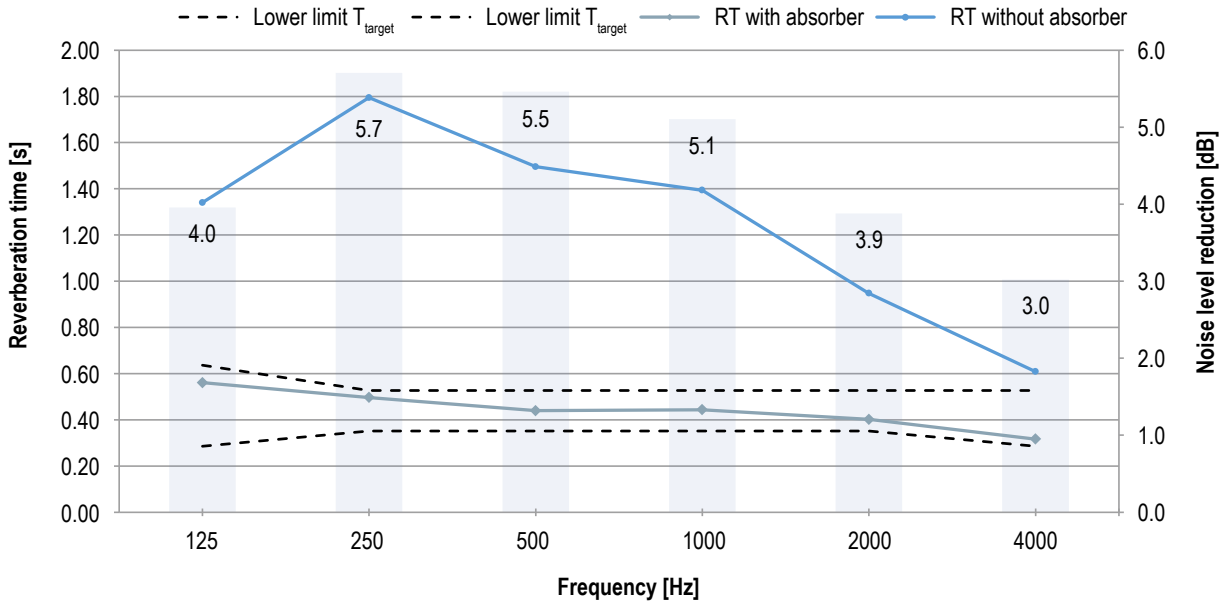
Input data for room acoustic prognosis

Room geometry

■ Length	12.5 m
■ Width	4.5 m
■ Height	3 m
■ Volume	169 m³

Materials used

■ Exterior wall	Glass façade
■ Corridor wall	Lightweight partition
■ Partitions	Lightweight partition
■ Floor covering	Needle punched carpets
■ Ceiling	Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 6 persons, without absorber	T = 1.26 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.35 – 0.53 s
Forecast reverberation time with absorber	T = 0.45 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	4 – 5 dB

The existing reverberation time may vary in dependence on the furnishings such as carpets, curtains, open book cases, couch upholstery, etc.

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Square perforation 8/18 Q	Construction depth 200 mm	Full surface
Wall absorber	Wall absorber Adit	–	1/3 of the front wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.75
Wall absorber	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Conference rooms without inclusion

Concept for conference rooms without inclusion

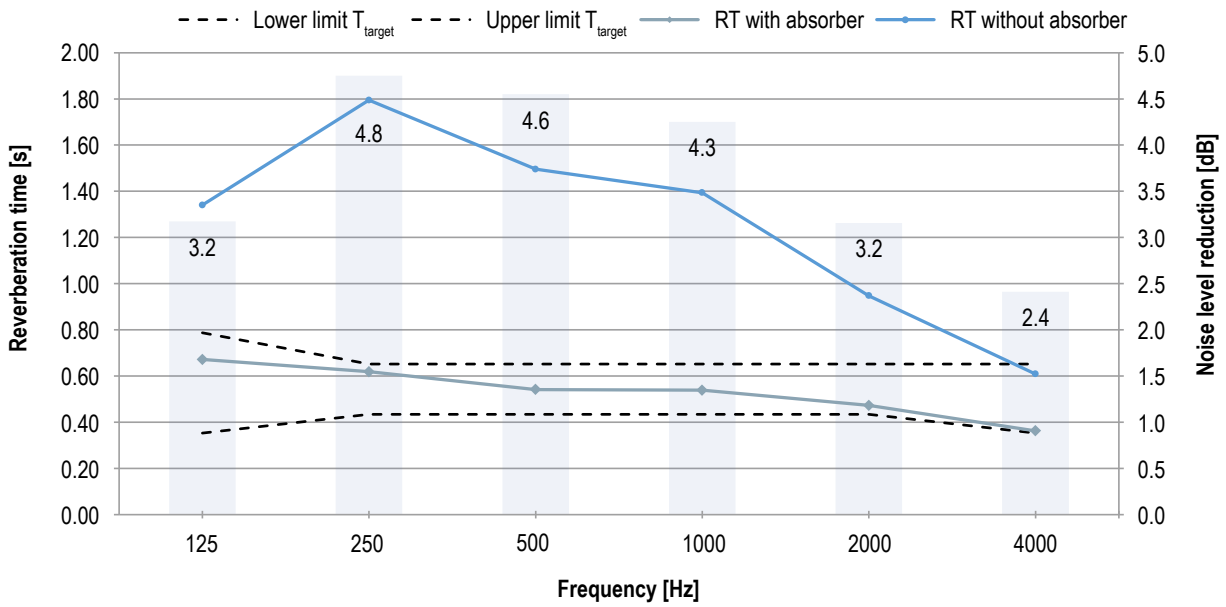
Input data for room acoustic prognosis

Room geometry

- Length 12.5 m
- Width 4.5 m
- Height 3 m
- Volume 169 m³

Materials used

- Exterior wall Glass façade
- Corridor wall Lightweight partition
- Partitions Lightweight partition
- Floor covering Needle punched carpets
- Ceiling Reinforced concrete ceiling



Room acoustical data	
Forecast reverberation time including 6 persons, without absorber	T = 1.26 s
Target reverberation time between 250 Hz to 2000 Hz	T = 0.43 – 0.65 s
Forecast reverberation time with absorber	T = 0.54 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Square perforation 8/18 Q	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	Wall absorber Adit	–	1/3 of the front wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.75
Wall absorber	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Sports halls

Concepts for sports halls

High levels of noise must be assumed with sport. Whether it is due to playing with a ball, talking loudly with one another, the loud cheers and encouragement from the crowd or a background music with rhythmic sporting disciplines. During leisure time everyone has the choice of whether they want to be exposed to this noise. With school sports neither the teachers or students have much choice in the matter. This is particularly true when there are parallel sports being played by several classes at the same time, where hardly any influence on the noise level is possible. Noise levels of 80 to 90 dB(A) are not the exception in sports halls and indoor swimming pools.

Sports halls and indoor swimming pools also have requirements on a target reverberation times to be observed. In comparison to the rooms previously described, the tolerance range is simply limited to the frequencies 250 Hz to 2000 Hz with an accuracy of ± 20%.

The sound absorbing materials must be distributed in the sports halls so that when the curtains are lowered the requirements on the target reverberation time, particularly in the middle section, are observed.

Measures which are undertaken must be implemented acc. to DIN 18032-1 to ensure ball impact safety.

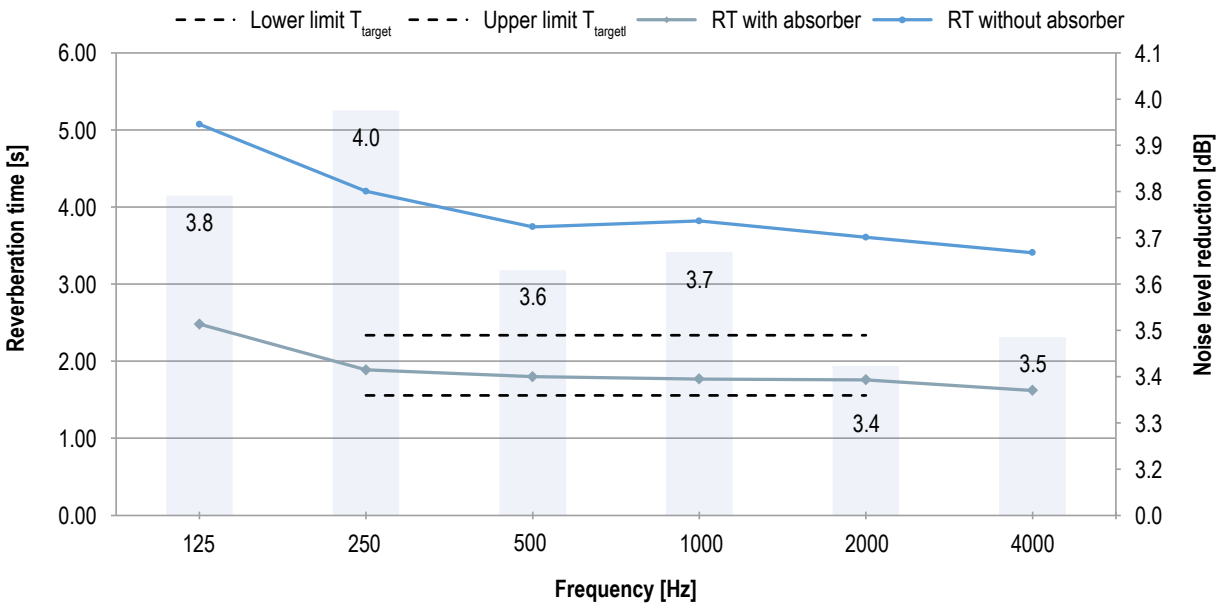
Input data for room acoustic prognosis

Room geometry

■ Length	45 m
■ Width	27 m
■ Height	7 m
■ Volume	8505 m³

Materials used

■ Exterior wall	Up to 2.5 m high impact wall, with brick masonry and profiled glass above it
■ Corridor wall	Up to 2.5 m high impact wall, with brick masonry and profiled glass above it
■ Partitions	Up to 2.5 m high impact wall, with brick masonry and profiled glass above it
■ Floor covering	Linoleum on a spring floor
■ Ceiling	Steel trapezoid sheet metal ceiling with beams



Room acoustical data	
Forecast reverberation time including 20 students, without absorber	T = 3.98 s
Target reverberation time between 250 Hz to 2000 Hz	T = 1.56 – 2.34 s
Forecast reverberation time with absorber	T = 1.80 s
Physical mean noise level reduction between 125 Hz to 4000 Hz	3 – 4 dB

The requirement is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Circular perforation 8/18 R	Construction depth 400 mm	50 % of the ceiling surface
Wall absorber	W623D.de Cleaneo Complete Wall Cladding Perforation pattern: Globe	Share of the surface Cleaneo Complete 2 m high strips from the upper edge of the impact wall Construction depth 77.5 mm	2 m higher, surrounding strips on the front walls and the corridor wall

Please note that in this part only the room attenuation level to combat higher noise levels is examined. A further decisive criterion for the reduction of the noise level with parallel sport lessons is sound insulation of the partition curtains which often leaves much to be desired according to studies of the Fraunhofer Institute for Building Physics (IBP) due to the design with openings, gaps between the boundary areas as well as poor seals in the area of the connection points to the stands.

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.60
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

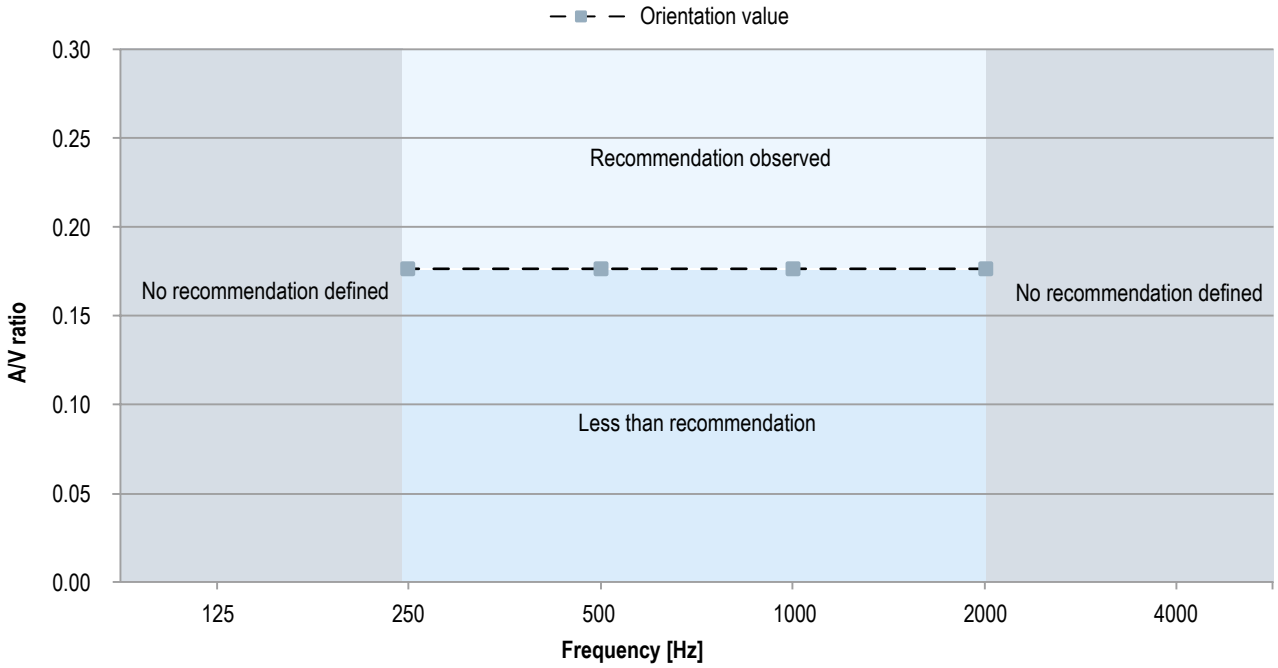
Fundamentals

Contrary to the provision of a sufficient supply of sound energy to all present, rooms of group B strive for a reduction of the noise level and the reduction of the acoustical liveness, so that a good intelligibility of voices is achieved only over short distances. Transfer of the sound over long distances is to be purposely avoided. In the DIN 18041:2016, an A/V ratio (equivalent sound absorption surface as a ratio to the room volume) over a frequency range between 250 to 2000 Hz is specified as a orientation value. The higher the figure value of this ratio, the greater the sound absorption surface located in the room and therefore the greater the acoustic attenuation within the room. This means there is a further large reduction in the noise level.

No tolerance range is specified in contrast to the requirement for rooms of group A. In fact, with the design of rooms of group B it is more important that frequency-dependent orientation value is practically achieved. Furthermore, the sound absorption by persons is not considered in the prognosis.

As the objective of a room acoustic design is to reduce the noise level of all noise and to reduce the level of the sound propagation in the room, there is no separate consideration of the enhanced demands with regard to a design with inclusion. Observing the agreed recommendation has a positive effect over short distances on people with hearing impairments, attention deficits and communication in a language that is not a native tongue.

Example representation of an orientation value between 250 Hz to 2000 Hz on the A/V ratio



One or two person offices

Concept for one or two person offices

In one and two person offices, as communication with colleagues or customers, personal discussions on a small scale or on the telephone take place and additional noise from outside the office can be heard, the orientation values for design of the room acoustic quality must be observed.

Often a one person office is converted into a two person office for re-utilization or space requirement reasons. Accordingly, identical recommendations are made for offices of this type.

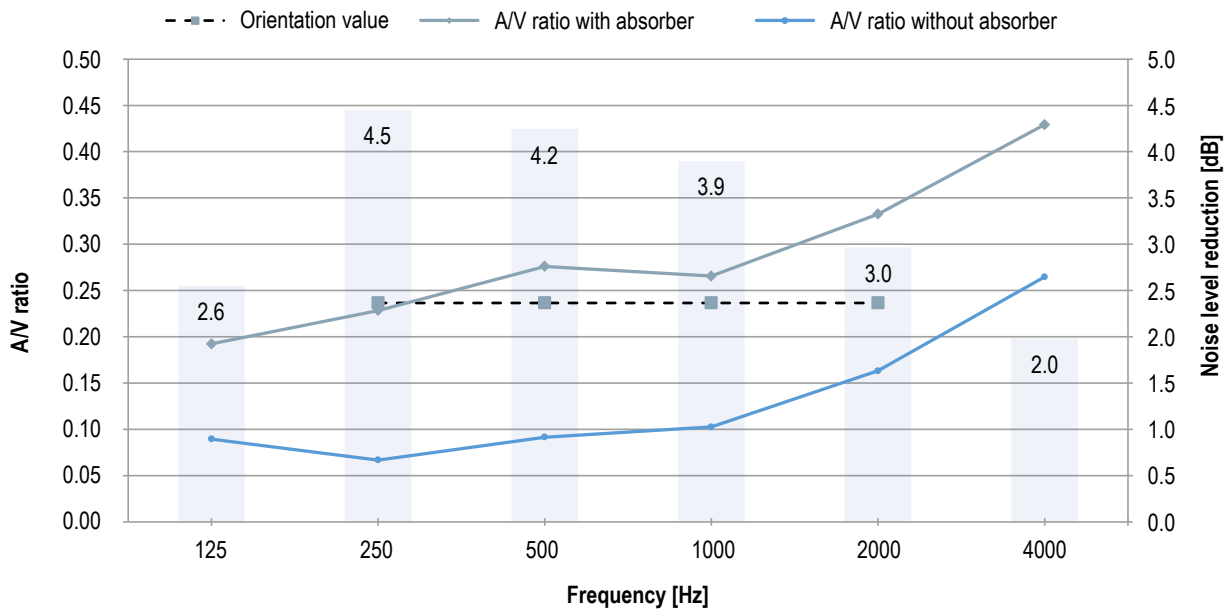
Input data for room acoustic prognosis

Room geometry

- Length 5.70 m
- Width 5.10 m
- Height 2.80 m
- Volume 81.4 m³

Materials used

- Exterior wall Plastered masonry with ribbon windows
- Corridor wall Lightweight partition
- Partitions Lightweight partition
- Floor covering Needle punched carpets
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.10 1/m
Recommended A/V ratio	A/V = 0.24 1/m
Projected A/V ratio with absorber	A/V = 0.28 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	3 – 4 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	Cleaneo Up	Format 1000 mm x 2000 mm, Construction depth 200 mm	4 pieces
Wall absorber	W112C.de Cleaneo Acoustic Wall Perforation pattern: Square perforation 12/25 Q	Wall thickness 132.5 mm	Share of the surface Cleaneo Acoustic Boards 50 %

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.65 with half ceiling surface coverage
Wall absorber	≥ 0.75

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Rooms of group B

Group and open plan offices

Concept for group and open plan offices

In particular with the design of group and open plan offices it is often insufficient to just consider the room attenuation level. During the planning phase it is important to ensure that functional groups with diverse requirements are not placed in a common area. Should this be unavoidable, effective, noise screening measures must be implemented to ensure a focussed and performance-orientated working environment. In team offices, ensure that the noise level is kept as low as possible. This begins already when purchasing necessary office equipment such as the printers or fans on the PC as well as during the design phase of the technical building system such as air-conditioning and ventilation. Good room acoustics also ensure the reduction of all noises in the room and reduces the speech volume of the occupants. Further recommendations for office rooms are dealt with in the VDI 2569.

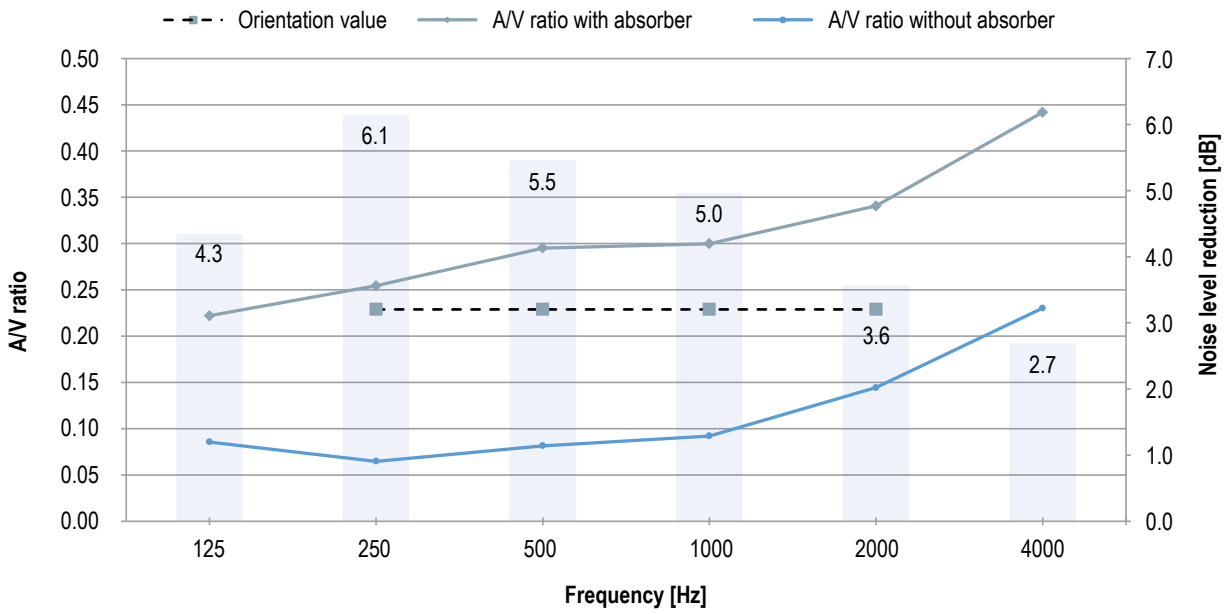
Input data for room acoustic prognosis

Room geometry

■ Length	15.0 m
■ Width	5.5 m
■ Height	3.0 m
■ Volume	247.5 m³

Materials used

■ Exterior wall	Plastered masonry with window front
■ Corridor wall	Lightweight partition
■ Partitions	Lightweight partition
■ Floor covering	Needle punched carpets
■ Ceiling	Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.10 1/m
Recommended A/V ratio	A/V = 0.23 1/m
Projected A/V ratio with absorber	A/V = 0.30 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	4 – 6 dB

The recommendation is met by the application of the following systems or products

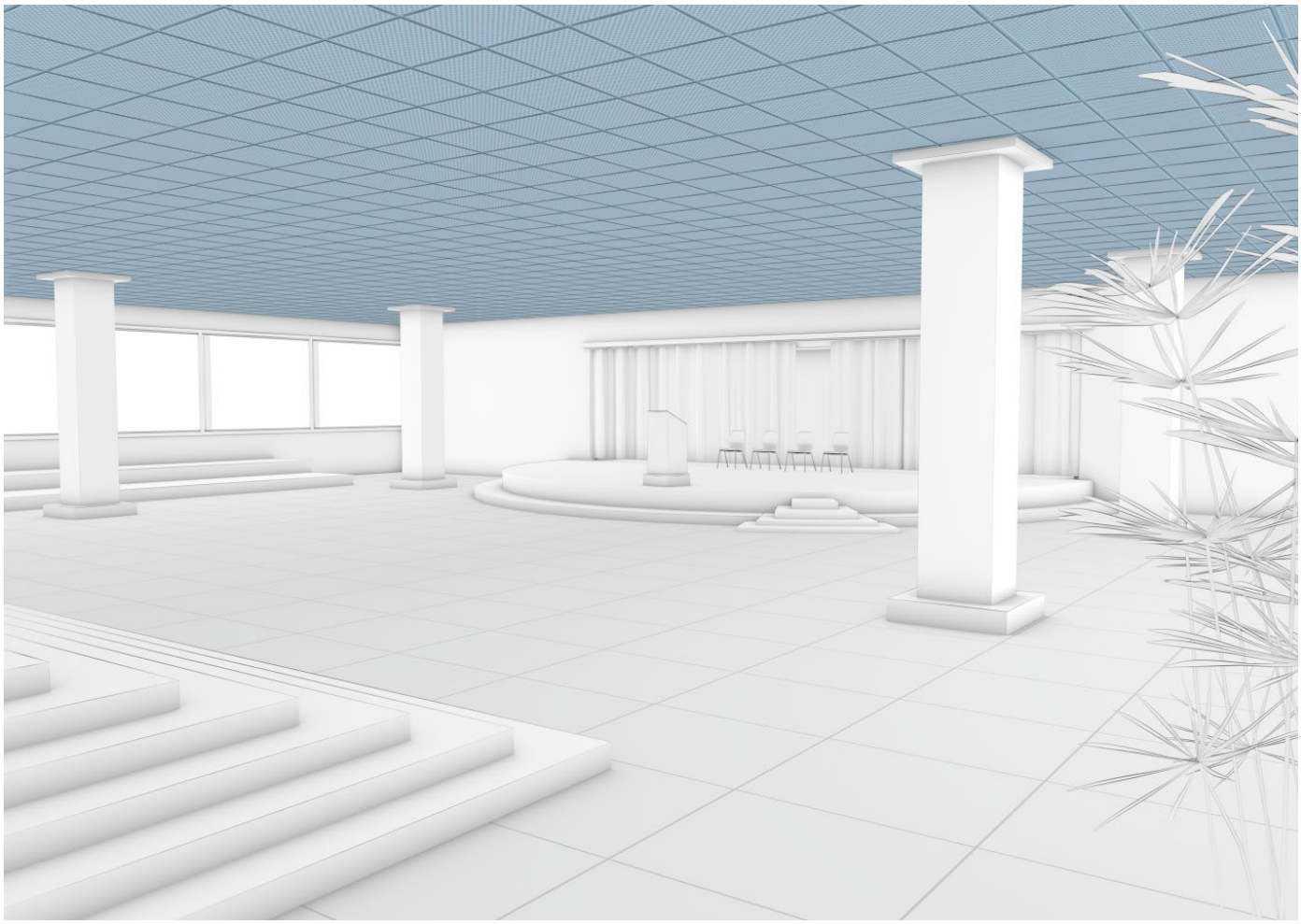
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Square perforation 8/18 Q	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	Adit	–	1/3 of the front wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.70
Wall absorber	≥ 0.80

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Assembly halls in schools



Concept for assembly halls in schools

Assembly halls in schools frequently serve several purposes. As a lounge for students during breaks, for musical recitals as well as verbal presentations during school events. Accordingly, the room acoustics must be designed so that communication with one another both in several groups as well as when only one speaker is on the stage or for musical performances are possible. As the main purpose of use intends the presence of schoolchildren, the assembly halls are to be treated at this point as rooms where you remain linger for longer similar to the heavily frequented areas in school and break rooms. If the purpose of the assembly hall is primarily intended for performances, the approach must be analogue to that of the auditoria or common rooms.

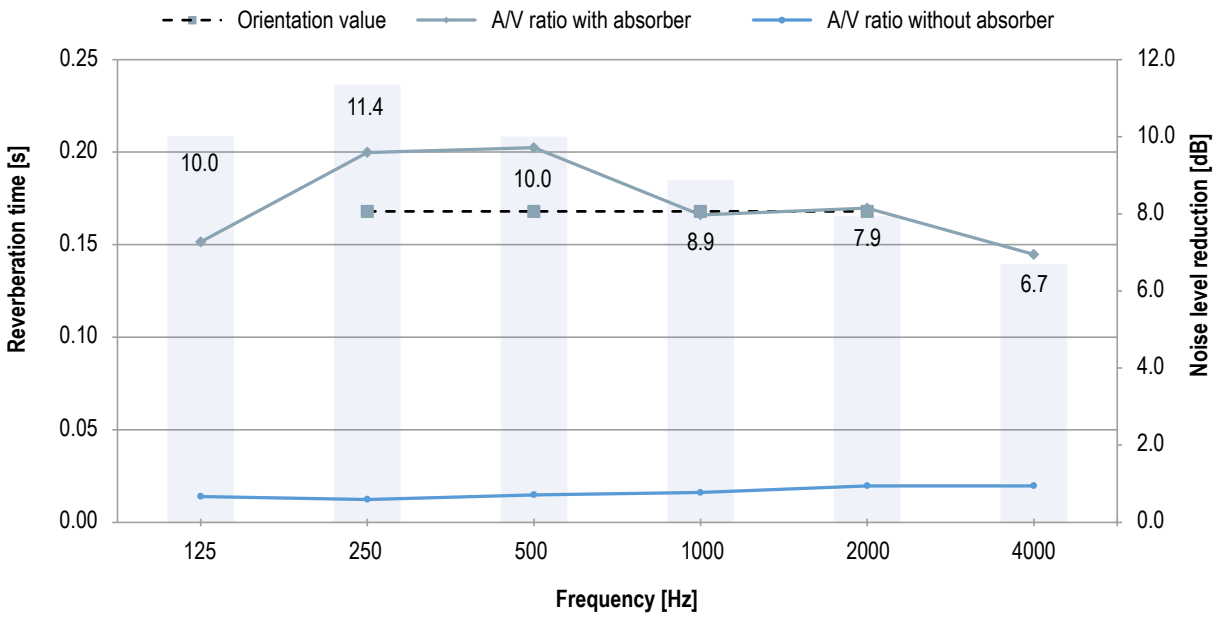
Input data for room acoustic prognosis

Room geometry

- Length 20.0 m
- Width 24.0 m
- Height 4.0 m
- Volume 1920 m³

Materials used

- Walls Reinforced concrete walls with glazing elements
- Floor covering Linoleum
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.02 1/m
Recommended A/V ratio	A/V = 0.17 1/m
Projected A/V ratio with absorber	A/V = 0.18 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	9 – 10 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D145.de Cleaneo Acoustical Dropped Ceiling Belgravia With mineral wool layer 30 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Globe	Construction depth 200 mm	Full surface

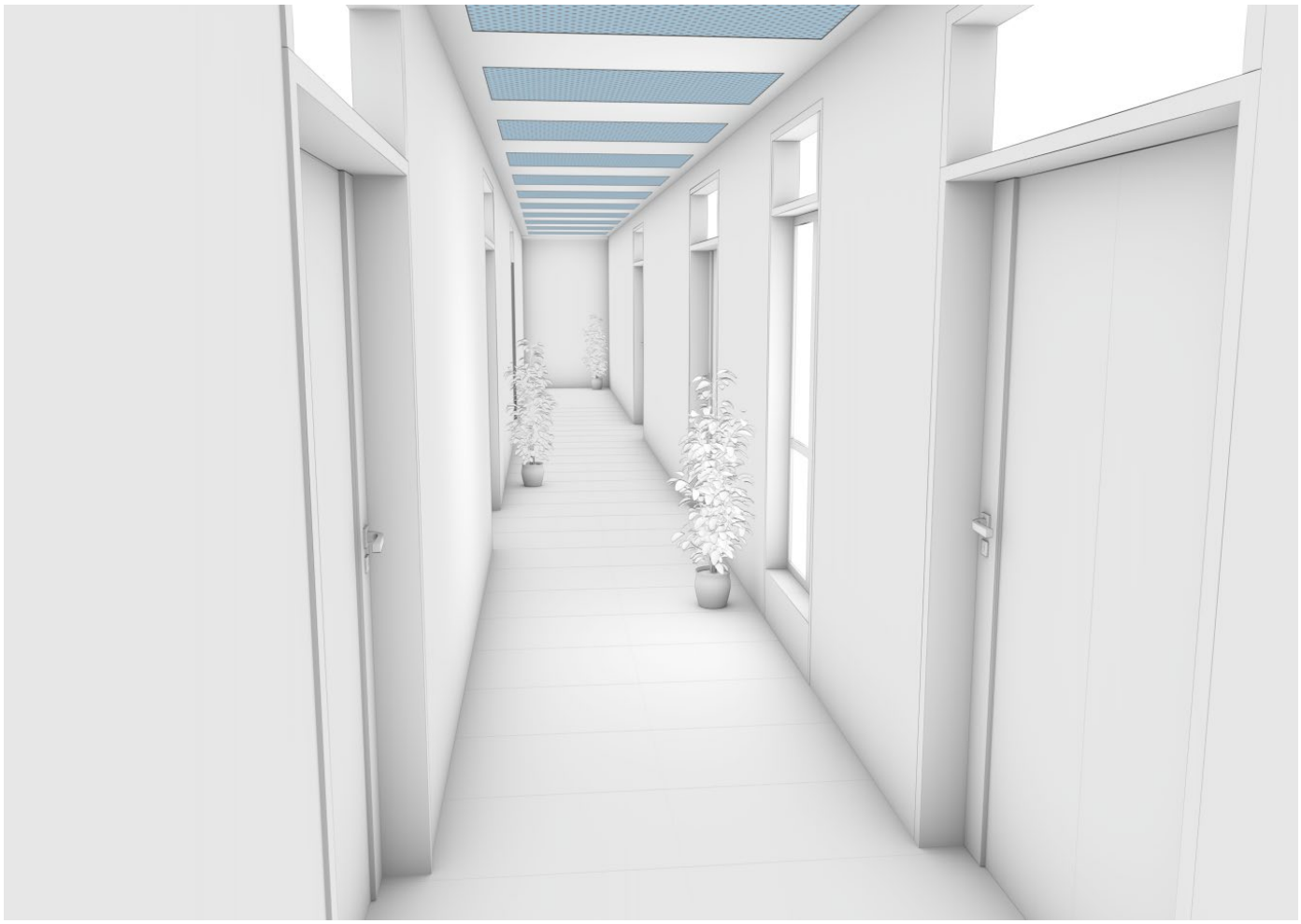
Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.60(L)

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Rooms of group B

Circulation areas



Concepts for circulation areas

Circulation areas are used in many institutions for communication interaction. In rooms without acoustical measures the noise level can be relatively high and spread across the whole storey as well as via the doors to the adjacent rooms. For this reason, the E DIN 18041 recommends in both apartment buildings in the access corridors as well as in public building such as hospitals, schools, kindergardens, etc. that room acoustical measures are implemented for circulation and trafficked areas.

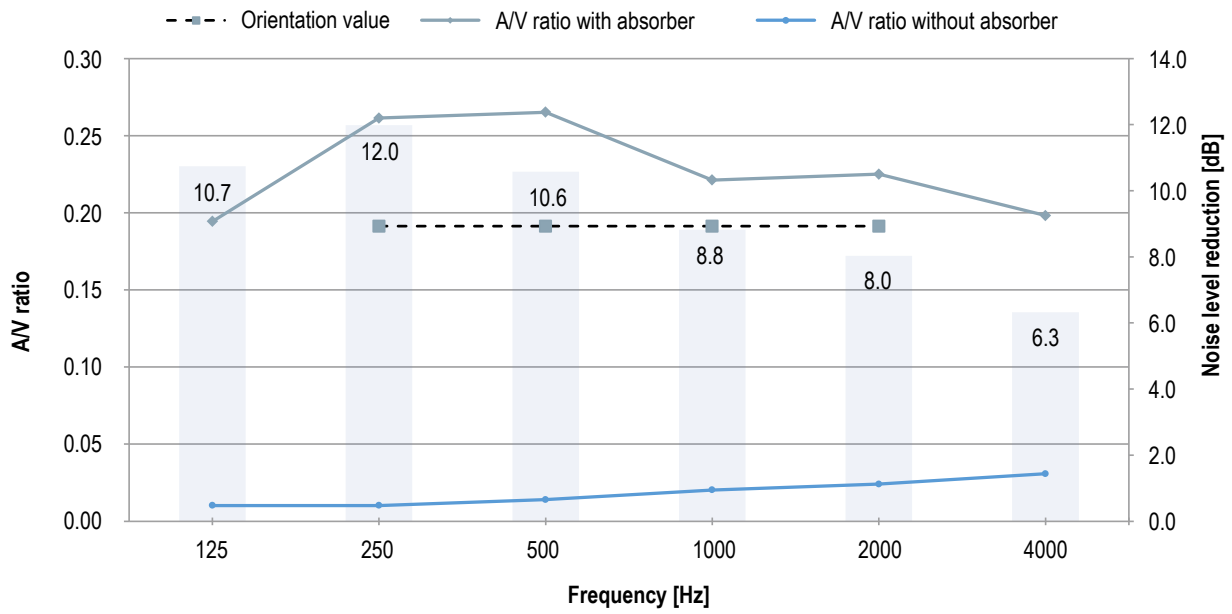
Input data for room acoustic prognosis

Room geometry

■ Length	20.0 m
■ Width	1.6 m
■ Height	2.8 m

Materials used

■ Walls	Plastered masonry
■ Floor covering	Tiles
■ Ceiling	Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.02 1/m
Recommended A/V ratio	A/V = 0.19 1/m
Projected A/V ratio with absorber	A/V = 0.24 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	9 – 10 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D146.de Acoustical Dropped Ceiling Plaza With mineral wool layer 30 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Globe	Construction depth 200 mm	1/3 of the ceiling surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.60(L)

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Cafeterias

Concepts for cafeterias

Cafeterias are not just intended as a place to get a quick bite to eat, but also a place to chat with customers and colleagues as well as being a place to regenerate and relax. In many cafeterias this is not possible without raising you voice to make sure that you can be heard. The permanently high noise level is an additional source of stress and does not permit relaxed communication.

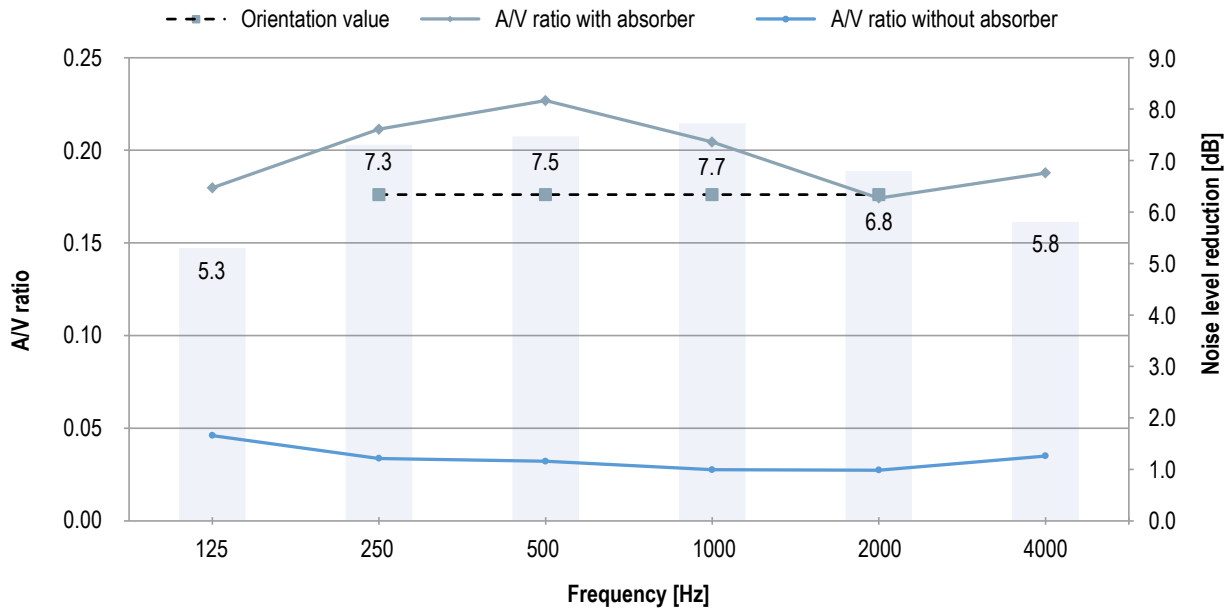
Input data for room acoustic prognosis

Room geometry

- Length 16.5 m
- Width 14.0 m
- Height 3.5 m

Materials used

- Exterior wall Plastered masonry with ribbon windows
- Interior walls Lightweight partition
- Floor covering Parquet
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.03 1/m
Recommended A/V ratio	A/V = 0.18 1/m
Projected A/V ratio with absorber	A/V = 0.20 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	7 – 8 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Random PLUS 10/16/22 R	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	W623D.de Acoustic Wall Lining Designpanel Perforation pattern: Tangent T3L1	Construction depth 65 mm	1/3 of the interior wall surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.55(L)
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Reception halls with workplace

Concept for reception halls and foyers

Reception halls and foyers due to their dimensions and the use mainly of acoustically hard materials are generally very acoustically lively. Accordingly, sound reflections on the boundary areas cause large echos and speech is very unclear. This is the case particularly when a permanent workplace with a counter is located in a reception hall. Conversations at reception, both personal as well as on the telephone can be heard in the entire room, making a confidential discussion almost impossible. Even the arrival of a visiting group and the associated communication, where more than one person may be speaking, could prove to be problematic due to the poor intelligibility of voices and the high noise level.

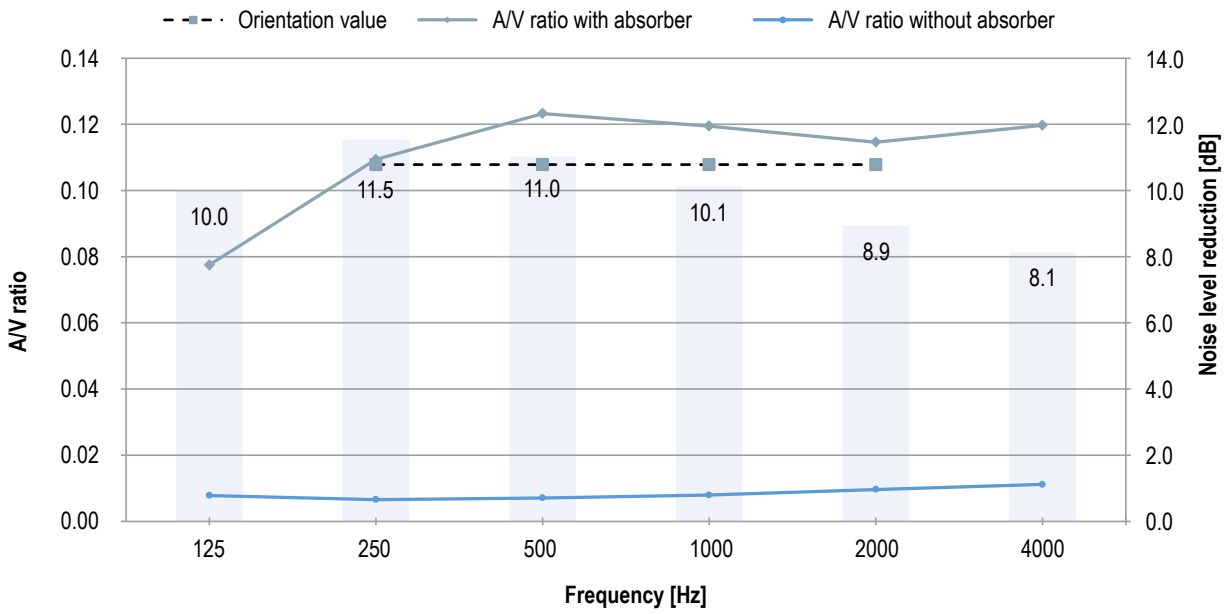
Input data for room acoustic prognosis

Room geometry

- Length 16 m
- Width 18 m
- Height 9.0 m

Materials used

- Exterior wall Glass façade integrated into the plastered masonry
- Partitions Unplastered masonry
- Floor covering Tiles
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.01 1/m
Recommended A/V ratio	A/V = 0.11 1/m
Projected A/V ratio with absorber	A/V = 0.12 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	10 – 11 dB

The recommendation is met by the application of the following systems or products

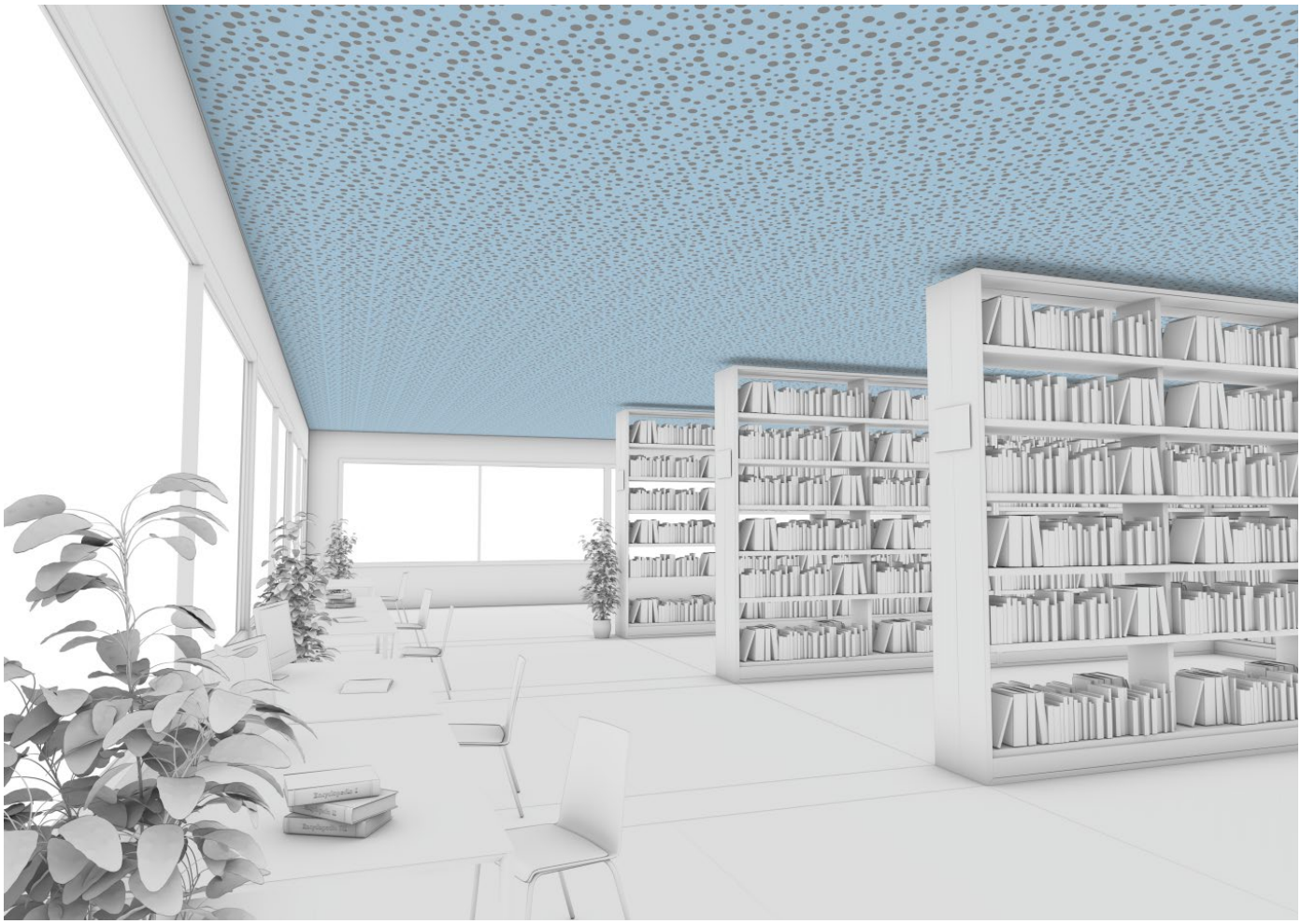
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Circular perforation 10/23 R	Construction depth 200 mm	2/3 of the ceiling surface
Wall absorber	W623D.de Acoustic Wall Lining Designpanel Perforation pattern: Tangent T3L1	Construction depth 65 mm	50 % of the interior wall surfaces

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.65
Wall absorber	≥ 0.70

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Library



Concept for libraries

Libraries are not just for lending books, but are also places to study. The demands on the concentration ability of the users in a library are accordingly high. The will in effect require an environment with the lowest possible level of noise, making the need for sound absorbing materials necessary. One large benefit of these types of rooms are the open shelves filled with books, folders and periodicals that offer a certain level of sound absorption characteristics. The more spartan the room, the more sound absorption that will be required. In quiet zones that only have tables and chairs, more measures will need to be implemented than in areas where there are book shelves.

The opaque boundary areas that are mainly occupied by book shelves usually exclude the use of a wall absorber. This is not absolutely necessary due to the sound absorbing characteristics of shelves filled with books.

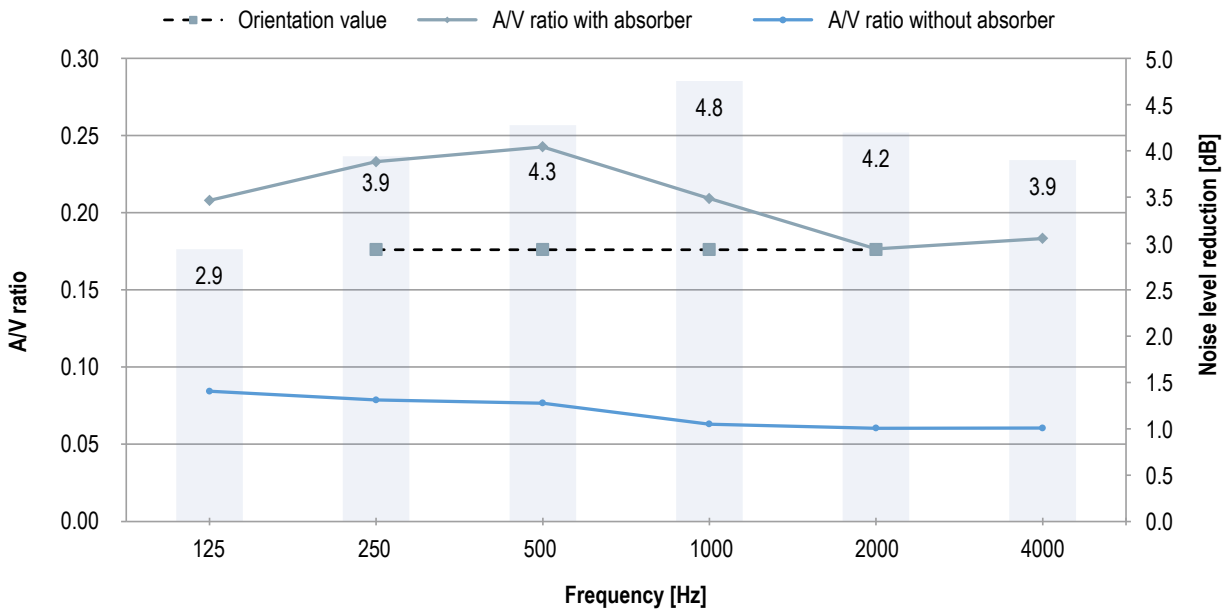
Input data for room acoustic prognosis

Room geometry

■ Length	22 m
■ Width	12 m
■ Height	3.5 m

Materials used

■ Exterior wall	Two plastered solid walls with window strip
■ Interior walls	Lightweight partition
■ Floor covering	Parquet
■ Ceiling	Suspended ceiling with gypsum board cladding (unperforated)



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.07 1/m
Recommended A/V ratio	A/V = 0.18 1/m
Projected A/V ratio with absorber	A/V = 0.22 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	4 – 5 dB

The recommendation is met by the application of the following systems or products

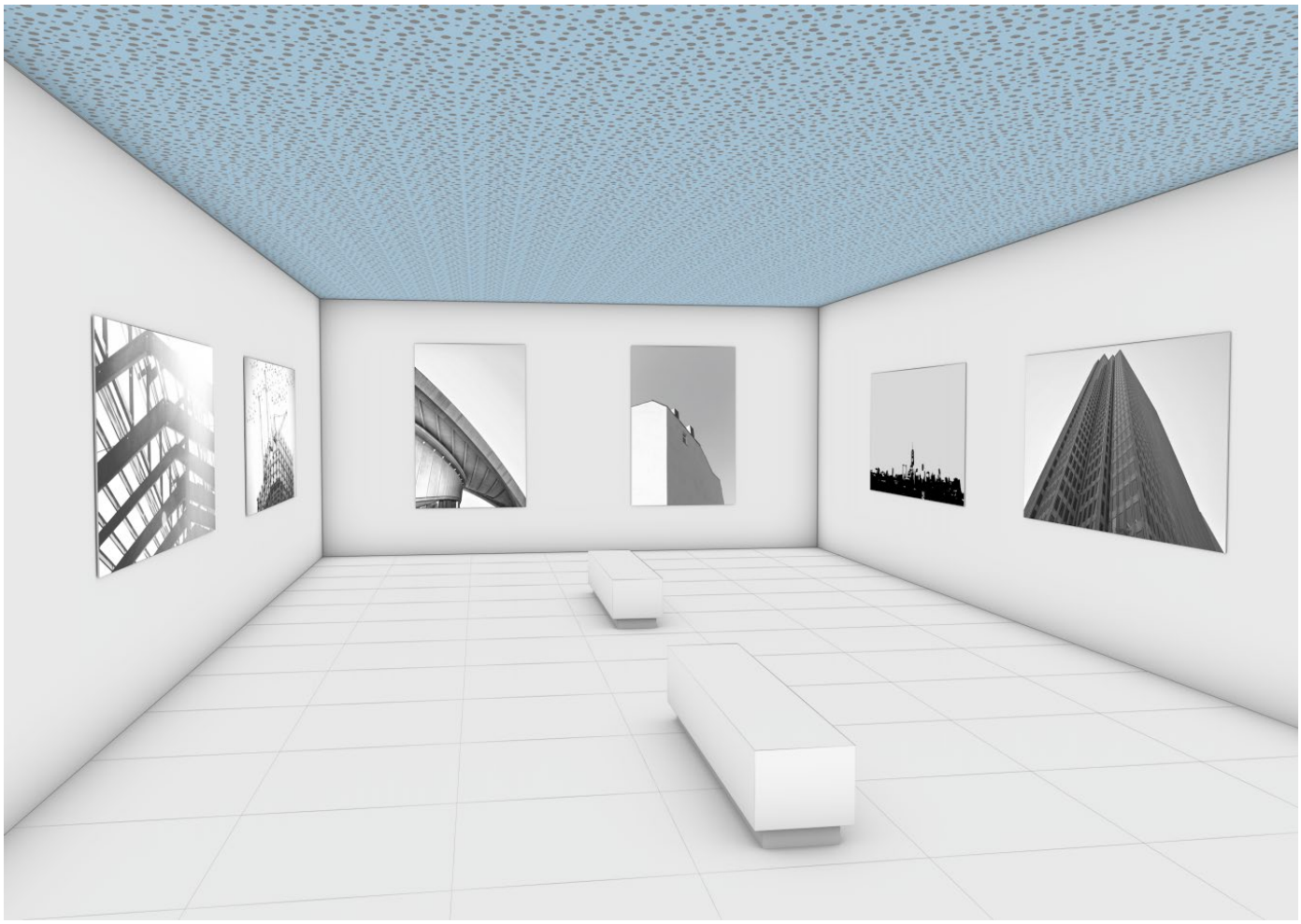
Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Random PLUS 10/16/22 R	Construction depth 200 mm	Full surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.55(L)

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Exhibition halls



Concept for exhibition halls

In the standard a differentiation is made for exhibition halls with and without interactivity. Interactivity includes multimedia renditions, sound and video art. Without interactivity the recommendations for the room acoustic quality are less stringent. However, it is practically impossible in advance to exclude that such activity will not be used in an exhibition hall or showroom. In order to keep the options open on future room usage, and thus offer artists and visitors the best possible environment for the corresponding art form, an exhibition hall with interactivity will be planned in the following example.

In exhibition halls the floor and wall surfaces are usually required for presentation of the exhibits. For this reason the acoustical measures are limited to the roof surface.

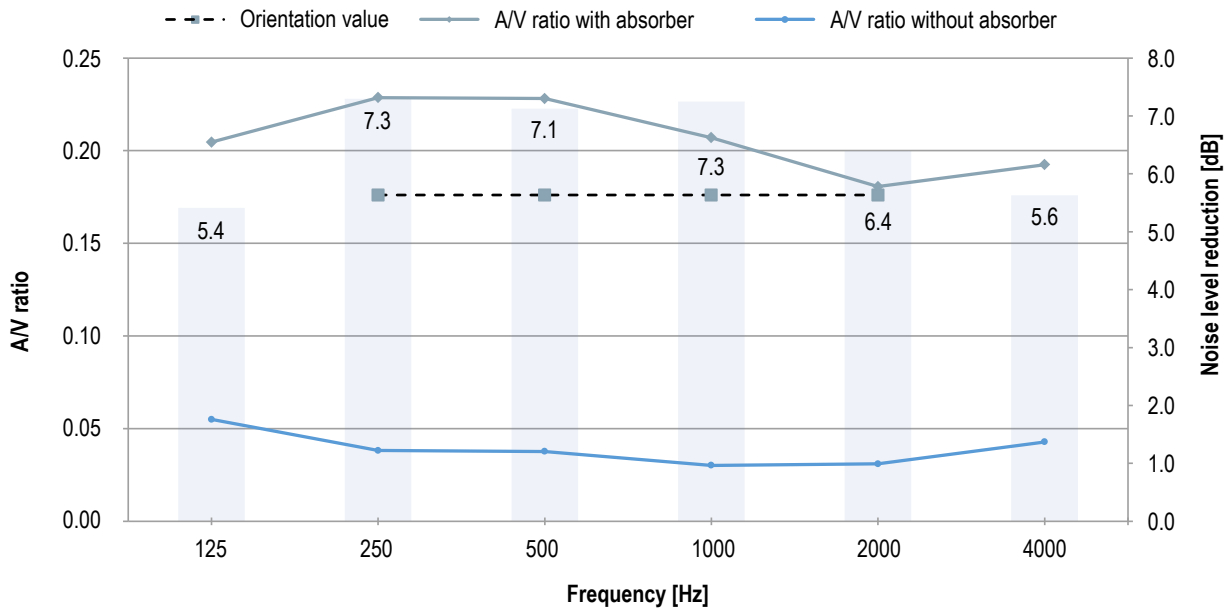
Input data for room acoustic prognosis

Room geometry

- Length 15 m
- Width 7 m
- Height 3.5 m

Materials used

- Exterior walls Concrete wall
- Interior walls Lightweight partition
- Floor covering Parquet
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.04 1/m
Recommended A/V ratio	A/V = 0.18 1/m
Projected A/V ratio with absorber	A/V = 0.21 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	7 – 8 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Random PLUS 10/16/22 R	Construction depth 200 mm	Full surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.65(L)

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Rooms of group B

Restaurants

Concept for restaurants

In restaurants there is usually a lot of value placed on the outward appearance. The room should be appealing and encourage you to linger. Room and colour concepts are developed to make it as comfortable as possible for the guest. What is often neglected is the second main purpose in addition to the meals. Conversation in pairs or in larger groups. It is not seldom that the room acoustical quality in restaurants is a hindrance to undisturbed conversations, because the background noise level is too high meaning that it is necessary to talk louder thus increasing the background noise level yet again. The objective of a room acoustic concept should be to provide a relaxed atmosphere permitting a conversation at an appropriate volume.

For dimensioning of the room acoustic measures the orientation values of room group B3 “Rooms where you remain linger for longer” should be applied.

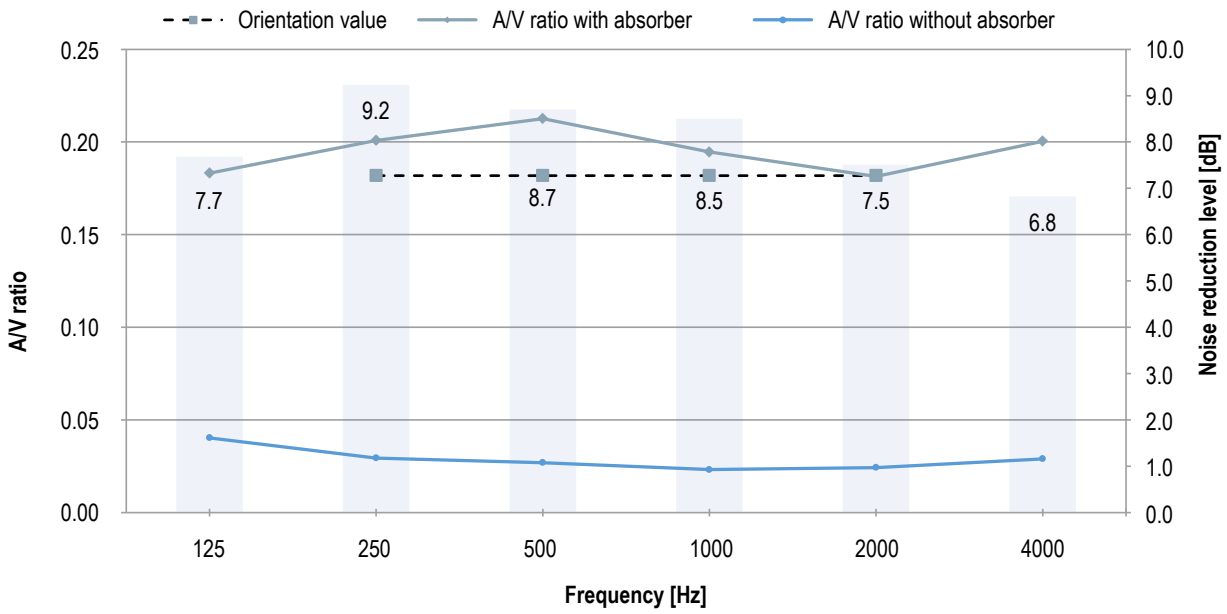
Input data for room acoustic prognosis

Room geometry

- Length 14 m
- Width 13 m
- Height 3.2 m

Materials used

- Exterior walls Plastered masonry with ribbon windows
- Interior walls Lightweight partition
- Floor covering Tiles
- Ceiling Reinforced concrete ceiling



A/V ratio between 250 Hz to 2000 Hz	
Projected A/V ratio without absorber	A/V = 0.03 1/m
Recommended A/V ratio	A/V = 0.18 1/m
Projected A/V ratio	A/V = 0.20 1/m
Physical mean noise level reduction between 250 Hz to 2000 Hz	8 – 9 dB

The recommendation is met by the application of the following systems or products

Acoustical measures	System / Product	Constructional specifications	Room acoustic effective installation
Ceiling absorber	D127.de Cleaneo Acoustic Board Ceilings With mineral wool layer 20 mm (Knauf Insulation Akustik-Dämmplatte TP 120 A or equivalent) Perforation pattern: Block perforation B6 with circular perforation 8/18 R	Construction depth 200 mm	Full surface

Absorbers with the following properties can be used as an alternative to the suggested systems or products

Absorber	Weighted sound absorption coefficient α_w:
Ceiling absorber	≥ 0.60

A product overview can be found in the technical brochure "Room Acoustics with Knauf - Data for planning"

Rooms of group B

References

St. Nikolaus evangelical Kindergarden

Company headquarters Knauf Gips KG

City library Hanau

St. Nikolaus evangelical Kindergarden

Group room

Requirement

- Room group A4 Common rooms in kindergardens
- Enhanced requirements with inclusion

Note

Additional projected occupancy rate of 80 % with children, acc. to DIN 18041

Room acoustical measures

Full surface covering of the ceiling with
D127.de Cleaneo Acoustic Board Ceilings
Perforation pattern: Standard circular perforation 8/18 R

Reverberation time acc to DIN EN ISO 3382

Target reverberation time acc. to DIN 18041:2016

Description of the room

Floor	Linoleum
Ceiling	Cleaneo Acoustic Board Ceiling Perforation design 8/18 R Perforation ratio 15.5 % Construction depth 65 mm With mineral wool layers
Walls	Wood panelling
Furnishings	Tables and chairs for 25 children, 3 carpets, books and shelves with toys

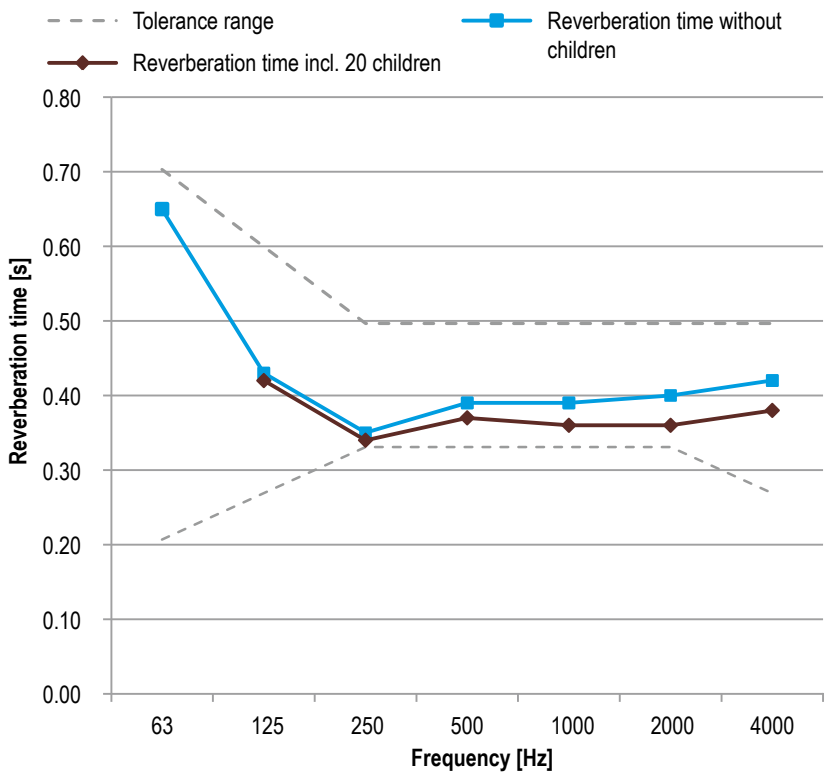
Occupied state of the room

Measurement performed without persons present

Data

Date of the measure-ment	13.07.2015
Measurement location	Kindergardens
Room designation	Common rooms in Kindergardens
Area	50.7 m²
Volumes	135 m³

Diagram



Frequency f Hz	Measured reverberation time without children s	Reverberation time with children s
63	0.65	–
125	0.43	0.42
250	0.35	0.34
500	0.39	0.37
1000	0.39	0.36
2000	0.40	0.36
4000	0.42	0.38

Average reverberation time between 125 Hz to 4000 Hz		
Without childen	$T_{m,without\ children}$ =	**0.40 s**
With children	$T_{m,with\ children}$ =	**0.37 s**

Knauf Gips KG
Am Bahnhof 7
97346 Iphofen
Germany

St. Nikolaus evangelical Kindergarden

Corridor

Requirement

Room group B3 Heavily frequented areas in schools and preschools

Room acoustical measures

Full surface covering of the ceiling with
D127.de Cleaneo Acoustic Board Ceilings
Perforation pattern: Standard circular perforation 8/18 R

St. Nikolaus evangelical Kindergarden

Reverberation time acc to DIN EN ISO 3382

Target reverberation time acc. to DIN 18041:2016

Description of the room

Floor	Linoleum
Ceiling	Cleaneo Acoustic Board Ceiling Perforation design 8/18 R Perforation ratio 15.5 % Construction depth 65 mm With mineral wool layers
Walls	Wood panelling, brick wall
Furnishings	Benches, cloakroom

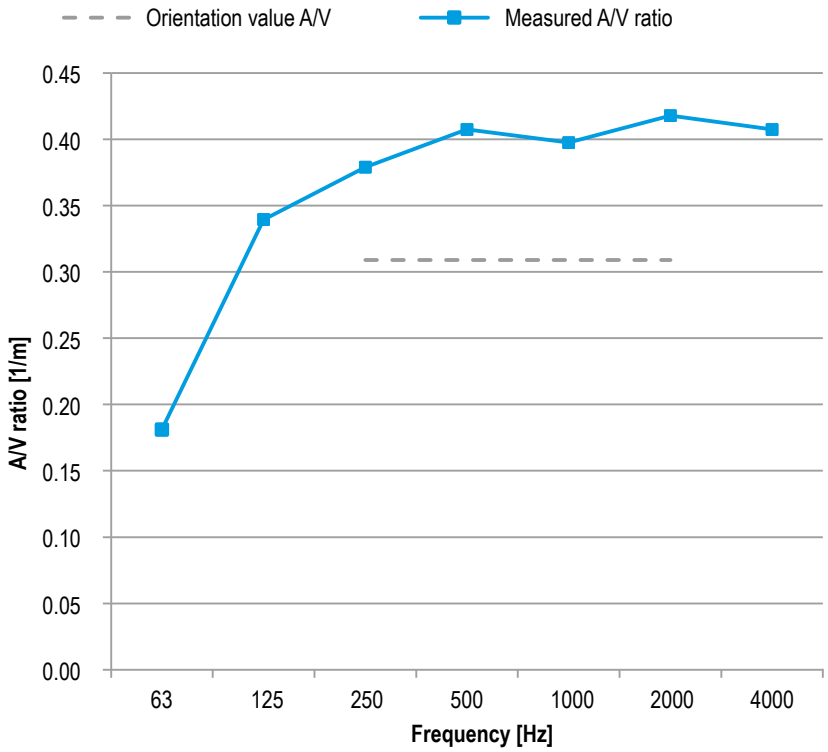
Occupied state of the room

Measurement performed without persons present

Data

Date of the measurement	13.07.2015
Measurement location	Kindergardens
Room designation	Play corridor in Kindergardens
Area	24.1 m²
Volumes	57.4 m³

Diagram



Frequency f Hz	Measured reverberation time s	A/V ratio 1/m
63	0.90	0.18
125	0.48	0.34
250	0.43	0.38
500	0.40	0.41
1000	0.41	0.40
2000	0.39	0.42
4000	0.40	0.41

A/V ratio averaged over the frequency range 125 Hz to 4000 Hz
0.40 1/m

Knauf Gips KG
Am Bahnhof 7
97346 Iphofen
Germany

Company headquarters Knauf Gips KG

Single person office

Requirement

Room group B4 Single and open plan offices

Room acoustical measures

Full surface covering of the ceiling with
D127.de Cleaneo Acoustic Board Ceilings
Perforation pattern: Standard square perforation 8/18 Q

Reverberation time acc to DIN EN ISO 3382
Target reverberation time acc. to DIN 18041:2016

Description of the room

Floor	Parquet
Ceiling	Cleaneo Acoustic Board Ceiling Perforation design 8/18 Q Perforation ratio 19.8 % Construction depth 100 mm With mineral wool layers
Exterior wall	Reinforced concrete wall with window strip
Interior partitions	Metal stud partition with GK cladding
Furnishings	2 tables, 9 chairs, wall unit

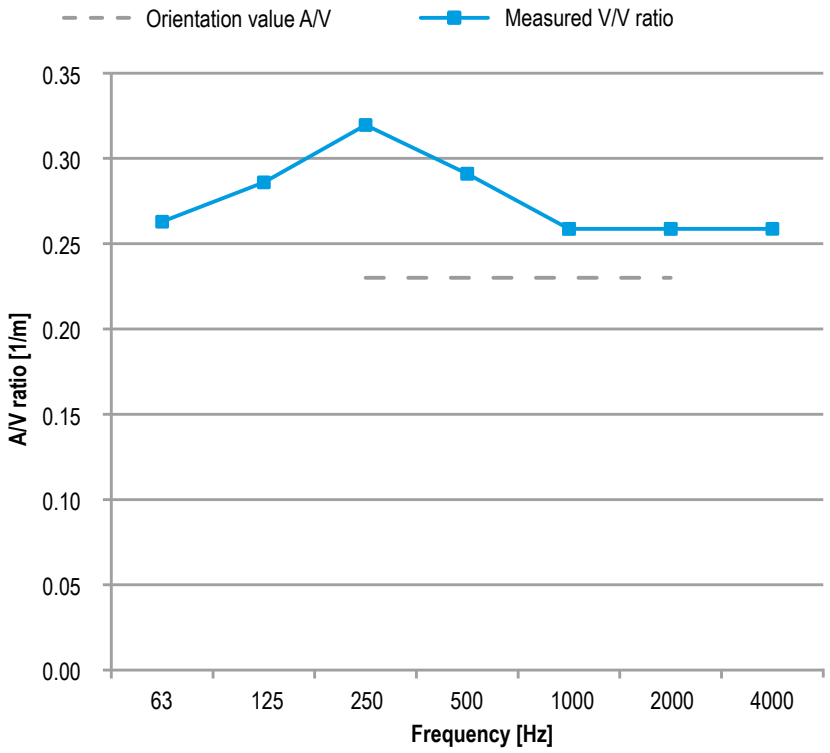
Occupied state of the room

Measurement performed without persons present

Data

Date of the measurement	23.06.2015
Measurement location	Knauf Gips KG, Iphofen
Room designation	Single person office
Area	33.4 m²
Volumes	103.0 m³

Diagram



Frequency f Hz	Measured reverberation time s	A/V ratio 1/m
63	0.62	0.26
125	0.57	0.29
250	0.51	0.32
500	0.56	0.29
1000	0.63	0.26
2000	0.40	0.26
4000	0.42	0.26

A/V ratio averaged over the frequency range 125 Hz to 4000 Hz
0.28 1/m

Knauf Gips KG
Am Bahnhof 7
97346 Iphofen
Germany

City library Hanau

Library

Requirement

Room group B3 library

Room acoustical measures

Full surface covering of the ceiling with
D127.de Cleaneo Acoustic Board Ceilings
Perforation pattern: Random Perforation PLUS 8/18/20

Reverberation time acc to DIN EN ISO 3382
Target reverberation time acc. to DIN 18041:2016

Description of the room

Floor	Carpet
Ceiling	Cleaneo Acoustic Board Ceiling Perforation design Random Perforation PLUS 8/18/20 Perforation ratio 13.1 % Construction depth 1100 mm With mineral wool layers
Walls	Solid walls with floor-to-ceiling window segments
Furnishings	In the measurement area about 30 book shelves Height 1.0 m to 1.8 m Length 2.0 m to 4.0 m

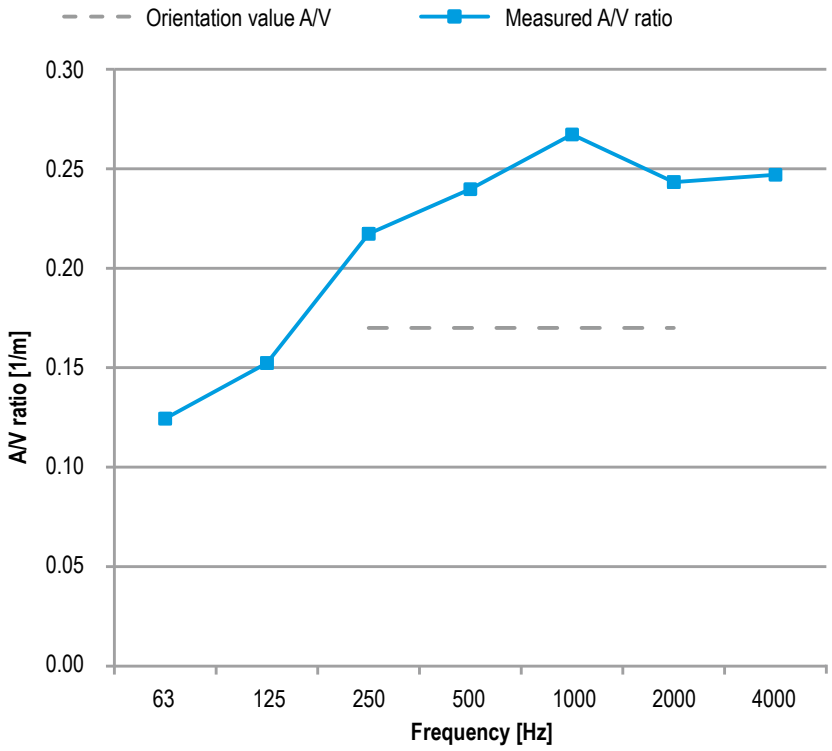
Occupied state of the room

Measurement performed without persons present

Data

Date of the measurement	05.08.2015
Measurement location	EKZ Hanau
Room designation	Library
Area	2675 m²
Volumes	10700 m³

Diagram



Frequency f Hz	Measured reverberation time s	A/V ratio 1/m
63	0.48	0.12
125	0.43	0.15
250	0.40	0.22
500	0.41	0.24
1000	0.39	0.27
2000	0.40	0.24
4000	0.42	0.25

A/V ratio averaged over the frequency range 250 Hz to 2000 Hz
0.24 1/m

Knauf Gips KG
Am Bahnhof 7
97346 Iphofen
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