VOGL DECKENSYSTEME

Acoustics and sound absorption

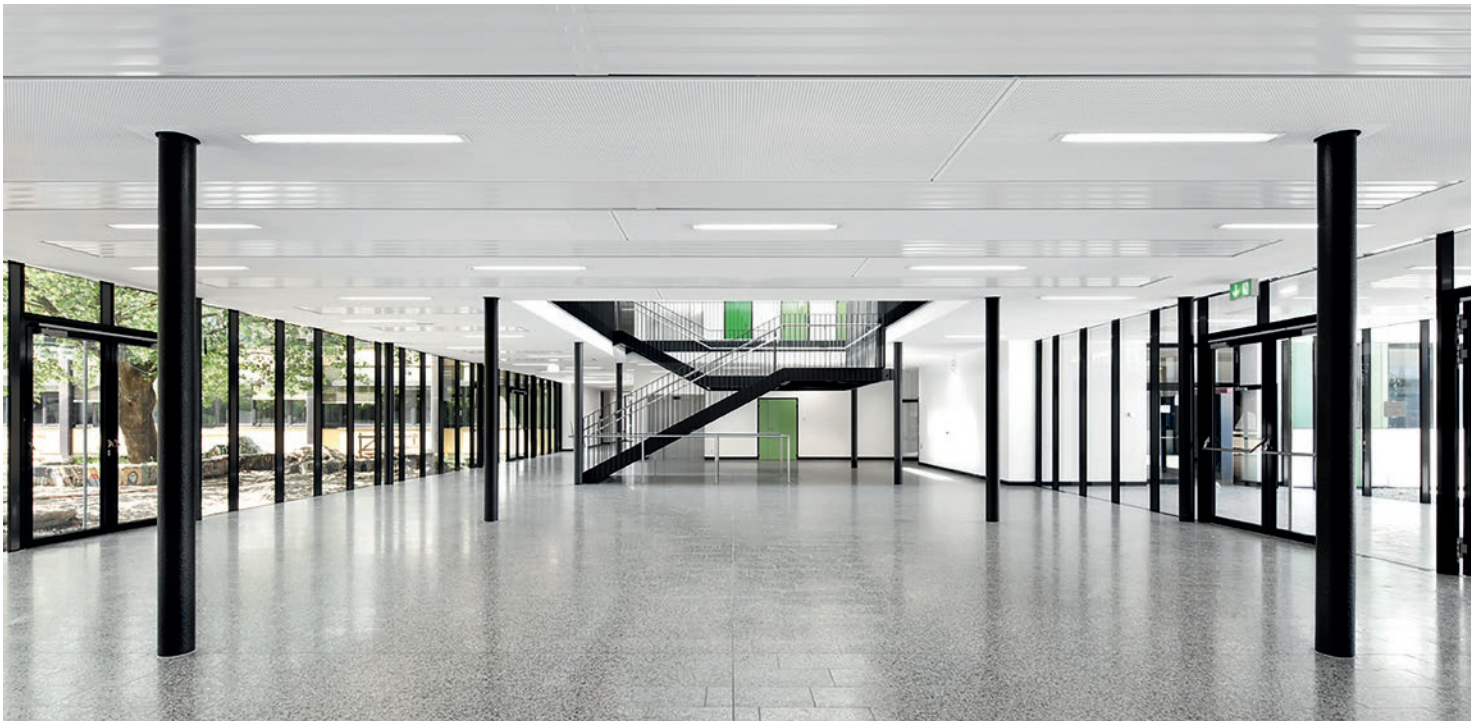
ACOUSTICS AND *DESIGN*

Acoustic is one of the elementary feel-good factors in a room.
In this context, a distinction is made between the areas of room acoustics and architectural acoustics. One of the crucial calculation and evaluation bases in room acoustics is the reverberation time within a room. The relevant frequency range is between 100 and 8.000 Hz.

In the following, you will be offered valuable insights into the effect of a holistic ceiling design on room acoustics and subsequently people using that interior.

CONTENTS *INTERESTING FACTS*

The contents and the values specified in this brochure refer to the applicable standards and requirements of room acoustic design in Germany. For other project locations, current and locally applicable requirements and regulations shall be observed at all times.



APPLICATIONS

SOUND ABSORPTION
APPLICATIONS

When it comes to the acoustic design of rooms, the absorption constitutes an essential element. Absorbing and reflecting surfaces "tune" the sound performance and thus determine the acoustic behaviour of a room.

It always takes an interaction of different absorbing and reflecting surfaces to achieve favourable room acoustics.

NOISE
REDUCTION

The noise intensity in a room is determined by the acoustic source and the existing sound absorption. Yet, the suitable kind of absorption directly depends on the type and the frequency range of the disturbing noise or sound. Whereas the reasonable amount is additionally determined by a cost-benefit consideration.

ROOM ACOUSTIC
DESIGN

When designing large rooms with sophisticated acoustics (such as opera houses, concert halls, theatres and lecture halls), the precise arrangement of reflecting and absorbing surfaces is of major significance along with an adequate level of absorption.

The room impression is determined not only by direct sound, but also, very essentially, by the relationship between early and late reflections (clarity index) and their input direction (lateral fraction).

In this context, each project has to be individually addressed by an acoustician, since, due to the respective conditions and room requirements, no general conclusions regarding "good" or "poor" absorption behaviour are possible.

REGULATION OF *REVERBERATION TIME*

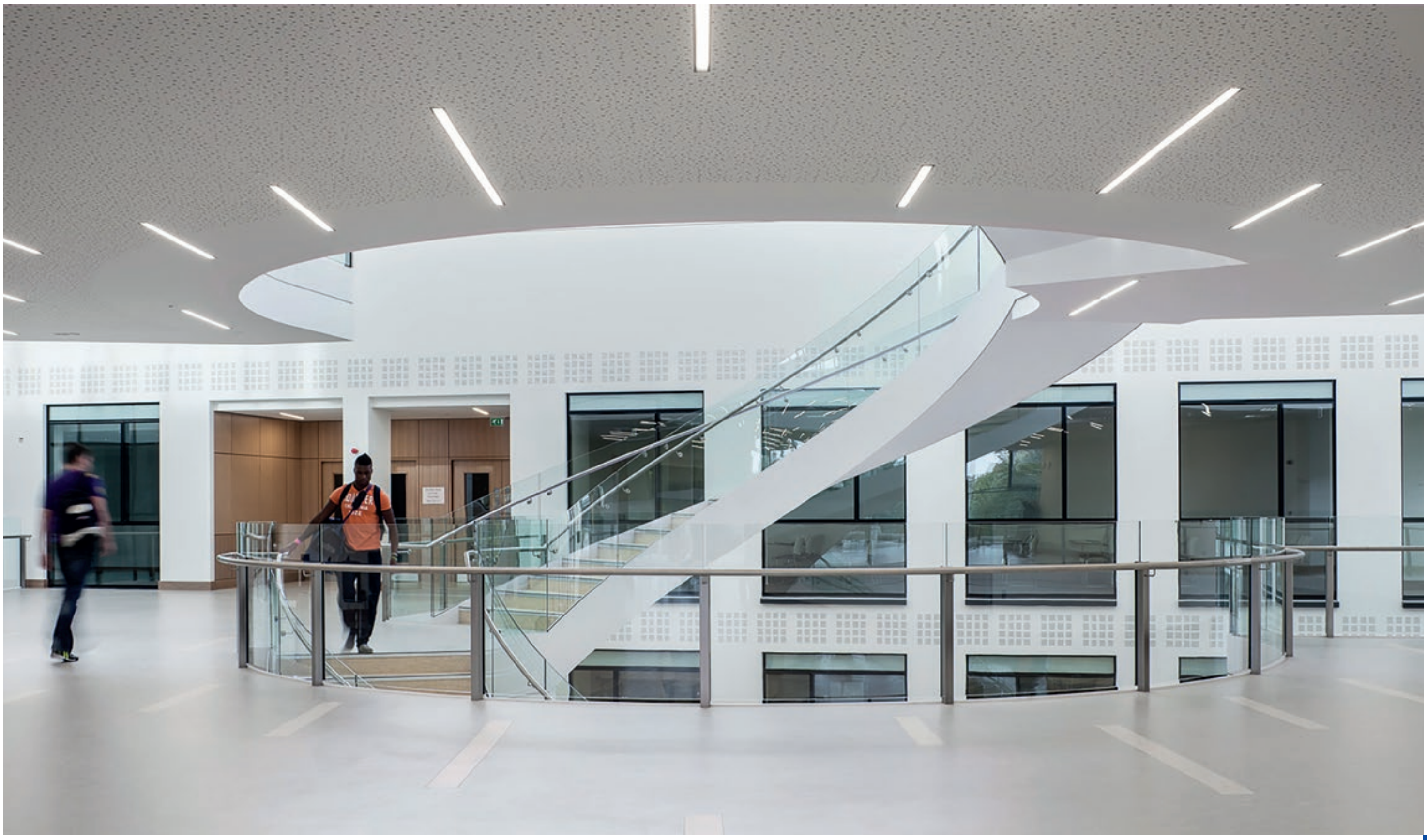
Music and speech should reach our ears in the same state they have been sent by the acoustic source (mouth, loudspeaker). The requirements regarding the reverberation in the room, that are formulated through the reverberation time T, depend on the use and volume of the room.

In practice, most surfaces have already been firmly installed before the acoustic design takes place. In addition to this existing absorption, wall and ceiling cladding with different absorption behaviour is required. Usually, the existing absorption is low in the lower frequencies, but close to sufficient in high frequencies – which calls for surfaces providing more absorption in lower and less absorption in higher frequencies.

A distinction shall be made between new construction projects and already existing rooms with regard to the room acoustic planning or optimisation of already existing acoustic performance.

> The reverberation time in office rooms requires regulation to ensure appropriate speech intelligibility. In addition to this, sound insulating measures in open plan offices shall be included for the sake of comfortable acoustic atmosphere. This can be achieved by using an absorbing ceiling design coupled with additional acoustic systems on the walls.

UNDERSTANDING ACOUSTICS



BASICS OF
SOUND ABSORPTION

Sound is a mechanical vibration of air molecules resulting in a propagating change in air pressure. The distance of an oscillation period is termed **wavelength l**; the oscillations per second are referred to as **frequency f**.

Speed of sound (air) c: at 20 °C
$c = \lambda * f \approx 343.2$ m/s $\approx$ 1,236 km/h

The frequency corresponds to the pitch. Thus, the deep and long-wave sounds have low frequency, whereas high sounds have a short-wave and high frequency range.

Limits of hearing and speaking ranges

- **Music**

  Frequency f: 20–20,000 Hz

  Wavelength λ: 17 m–0.0017 m

- **Speech**

  Frequency f: 250 Hz–2,000 Hz

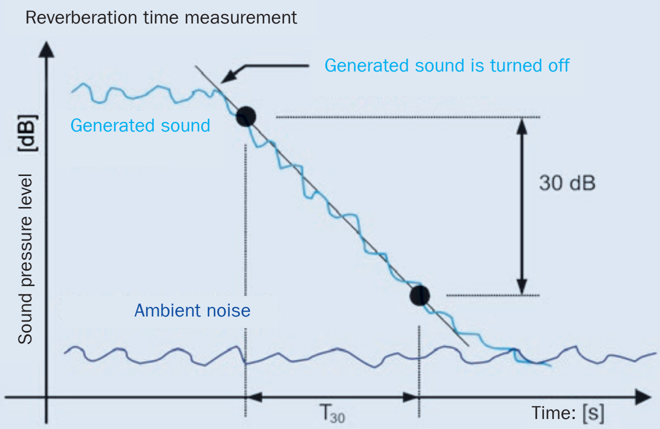
  Wavelength λ: 1.72 m–0.17 m

- **Room acoustics** (relevant frequency range)

  Frequency f: 100 Hz–8,000 Hz

  Wavelength λ: 3.43 m–0.069 m

Average sound absorption coefficient $\overline{\alpha}$:



Reverberation time: $T = T_{60} = T_{30} \cdot 2$

PITCH – FREQUENCY

Sound-absorbing elements in a room

EQUIVALENT SOUND ABSORPTION AREA

The term sound absorption describes the loss of energy when a sound wave hits a surface. Then again, the sound absorption coefficient defines the correlation between the absorbed and the impacting energy, and indicates total absorption with a value of one.

The equivalent **sound absorption area A** virtually results from the absorption coefficient α of a material and its surface S:

$A = \alpha * S\ [m^2]$

The total absorption $\mathbf{A_{tot}}$ present in the room consisting of the absorption of surfaces (wall, floor, ceiling, window...) as well as the absorption of furnishings, people and the air is calculated as follows:

$A_{tot} = S_W \cdot \alpha_w + S_F \cdot \alpha_F + S_C \cdot \alpha_C + A_{Fr} + A_P + A_A\ [m^2]$

The total sound absorption A_{tot} divided by the total surface S_{tot} results in the average **sound absorption coefficient** $\bar{\alpha}$.

> The impact of noise can have a detrimental effect on health. For this reason, a noise level of 35 dB(A) during the day and 30 dB(A) at night is recommended for, e.g., relaxation rooms or bedrooms.

SOUND ABSORPTION IN THE ROOM

Absorption and reflection of surfaces

Acoustic ceilings

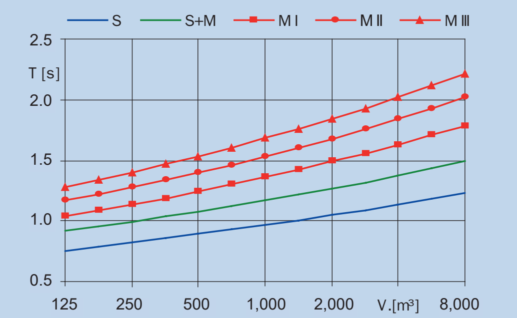
Sound absorption

REVERBERATION TIME

The reverberation time as an important parameter of room acoustics is a general measure for the acoustic quality of a room because it allows conclusions to sound intensity and tone colour, clarity and transparency, reverberation and spatial impression.

For every room, there is a desirable reverberation time depending on its purpose of use and its volume. The correlation between reverberation time and equivalent absorption areas results in the requirement for absorption.

Desirable reverberation time depending on room volume



S: Verbal presentation, **S+M:** Speech and music, **M I:** Solo and chamber music, **M II:** Symphonic music, **M III:** Organ

SABINE EQUATION

The reverberation time T is the most important and best-known criterion of room acoustics. It determines the time required for the sound pressure level to decrease by 60 dB after the acoustic source has been turned off.

$T = 0.163 \times V / A = 0.163 \times V / \alpha \times S_{tot\ [S]}$

The Sabine equation forms the basis for room acoustic calculations.
A precondition for the validity of this equation is a diffuse sound field, i.e., a uniform distribution of the sound energy throughout the room. It is fulfilled if:

- The sound absorption is distributed relatively evenly on all surfaces.
- The existing average sound absorption is too high ($\bar{\alpha} \leq 0.25$).
- The deviation from a cube shaped room is not too big (aspect ratio up to approx. 1:5).
- The room volume is smaller than 2,000 m³.

Nowadays, complex computer programs are available that accurately simulate acoustic processes. However,this calculation process is very elaborate and is usually applied only to large rooms with complex acoustics, such as opera houses, theatres, lecture halls and the like.

Diffusers:

If there is no diffuse sound field, so-called diffusers can create one. In practice, these are mainly furnishing objects or people. If they are not included into the calculation to the full extent, the resulting reverberation time can deviate from the original requirement.

The necessary absorption A can be calculated from the required reverberation time T and the room volume V by means of formula adjustment.

Sound absorption A of the empty room

$$A = 0.163 \cdot V / T \qquad [m^2]$$

Rated sound absorption α_w

As opposed to the US standard ASTM C 423, the German standard DIN EN ISO 354 does not contain any single number ratings. Since 1997, DIN EN ISO 11654 "Sound absorption for application in buildings" exists, which forms a single number from the measured values (according to DIN EN ISO 354):

First, the three one-third octave values of each octave are averaged and rounded in increments of 0.05. The six values resulting from that, practical absorption coefficient α_p, replace the measured values.

Then, the reference curve (see example) is shifted downwards (in increments of 0.05) until the total of values below the reference curve is smaller than or equal to 0.10. The rated absorption coefficient α_w is the value of the reference curve at 500 Hz. If α_p in one (or several) frequencies is above the shifted reference curve by 0.25 or more, α_w has to be supplemented by one (or several) shape indicators: L (low) at 250 Hz, M (middle) at 500 or 1,000 Hz, H (high) at 2,000 or 4,000 Hz. Appendix B of DIN EN ISO 11654 includes a classification of the single number rating, i.e., α_w is broken down into absorption classes:

MEAN VALUES
IN PRACTICE

Single number ratings, i.e., mean values, are often necessary for practical reasons (but are mostly inadequate for meaningful acoustic designs).

Arithmetic mean (i.M.) value $\alpha_{i.M.}$

The 18 one-third octave values (6 octave values) of sound absorption are added and divided by 18 (6).

Noise Reduction Coefficient NRC

The US standard ASTM C 423 "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method" corresponds to the standard DIN EN ISO 354 "Measurement of sound absorption in a reverberation room". ASTM C 423 additionally includes the determination of a single number:

The four one-third octave values at 250, 500, 1,000 and 2,000 Hz are added and divided by 4. The result is rounded in increments of 0.05.

SOUND ABSORPTION

Classification of absorbers as per DIN EN ISO 11654

Class	α_w	Class	α_w
A	0.90 ... 1.00	D	0.30 ... 0.55
B	0.80 ... 0.85	E	0.15 ... 0.25
C	0.60 ... 0.75	n.c.	0.00 ... 0.10

n.c.: not classified

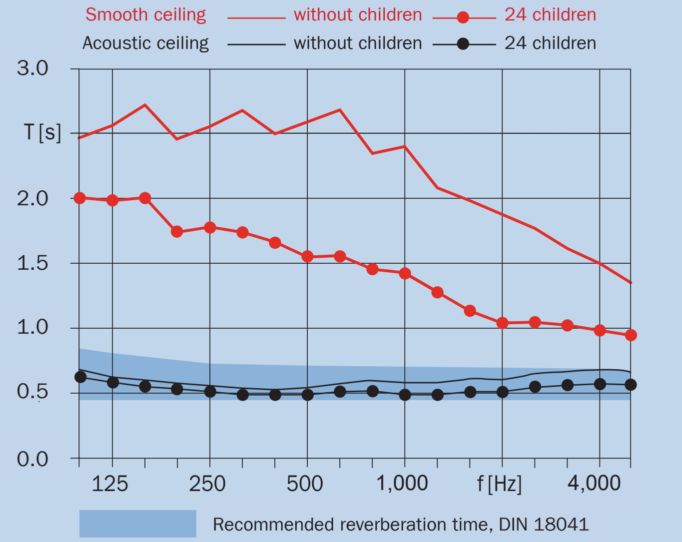
EXAMPLE
CLASSROOM

Good speech intelligibility is the prerequisite for an agreeable communication between teachers and pupils. Poor speech intelligibility requires increased concentration, diminishes performance and reduces the effectiveness of lessons.

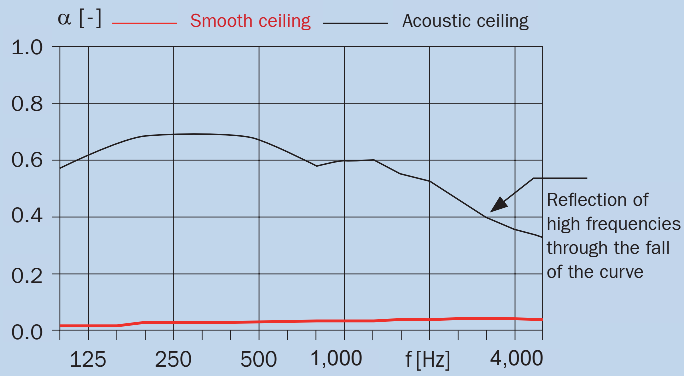
The requirement for good speech intelligibility is an appropriate reverberation time. DIN 18041 "Acoustic quality in small to medium-sized room" provides the relevant guideline values.

The reverberation that people subjectively perceive as pleasant also depends on the size of the room. The smaller the room, the shorter the reverberation time should be. Yet in larger rooms, greater reverberation time is expected.

Measured reverberation time in the classroom
(exemplary situation without reference to the image)



Absorption of ceiling



REVERBERATION TIME
IN THE CLASSROOM

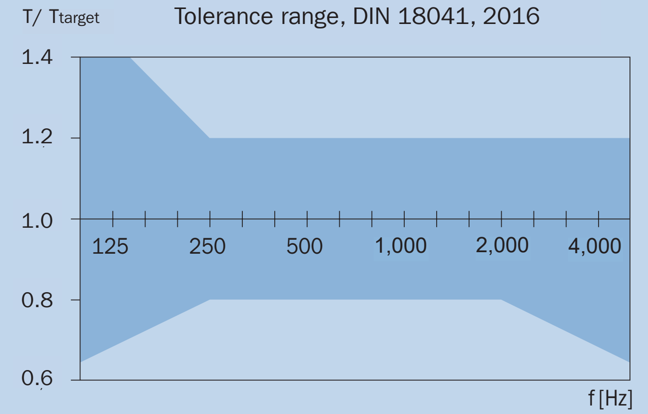
The reverberation time is to be as consistent as possible from 100 to 5,000 Hz. This is to ensure that the sound travels from teacher to pupil without being distorted. DIN 18041 includes a tolerance range for this purpose (see graphic):

In lower frequencies, the reverberation time may slightly increase and in higher frequencies it may slightly decrease. This great tolerance has no acoustic justification, but is a concession to practice. Because usually, there is a lack of absorption in the lower and a surplus in the higher frequency ranges.

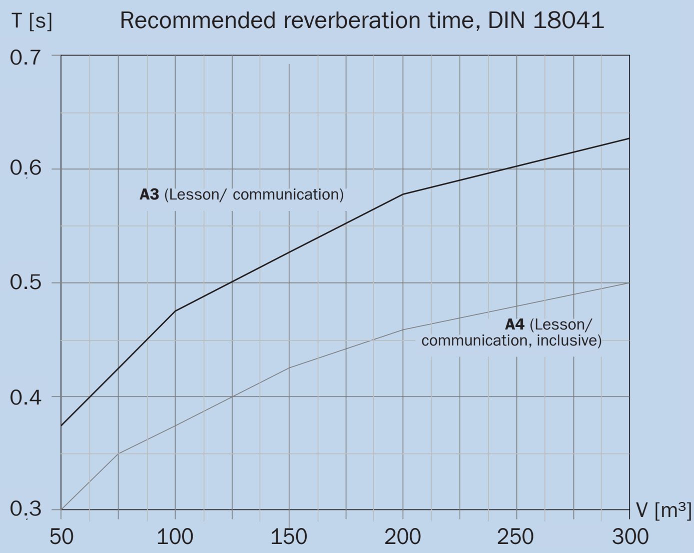
Along with wall and floor coverings or textile room furnishing, it is above all the ceiling that can help to optimise the reverberation performance. The selection of an optimum ceiling is based on the required reverberation time, the fixed room volume and the existing basic equipment. Measuring results from a classroom (see graphic, p. 11) give impressive evidence of this.

With the curve of absorption being ideal for the classroom, the reverberation is reduced to the right balance. At the same time, the high frequencies essential for intelligibility are adequately reflected in the rear area of the classroom.

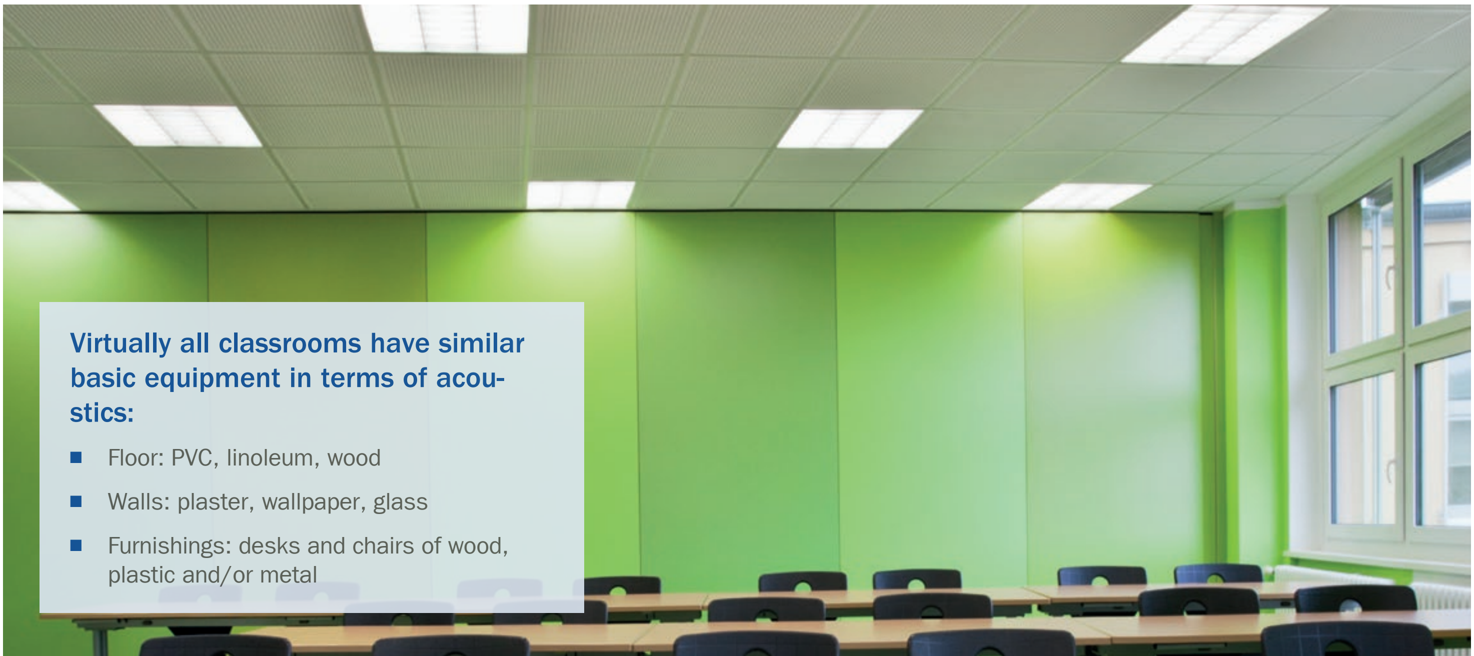
Tolerance range depending on frequency



Reverberation time depending on room volume



ACOUSTIC CEILINGS



Virtually all classrooms have similar basic equipment in terms of acoustics:

- Floor: PVC, linoleum, wood
- Walls: plaster, wallpaper, glass
- Furnishings: desks and chairs of wood, plastic and/or metal

PRACTICE-ORIENTED DESIGN

In large lecture halls (exceeding 80 m² / 250 m³ / 50 people), the following measures, for instance, should be taken:

- Absorbing design of the ceiling frieze as well as of the upper areas of side and rear walls
- Reflecting ceiling plan to allow the sound to be directed towards the rear of the room
- Additional reflectors on the front and rear wall

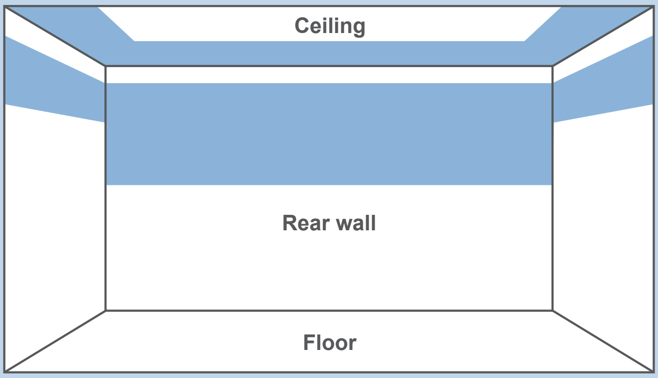
Note: DIN 18041:2016 additionally indicates other designs for absorber distribution (Section 5.4).

In small classrooms (< 60 m² / 200 m³ / 30 children), i.e., if the distance between the teacher and the pupils is smaller, acoustic details can be cut down on in order to save costs:

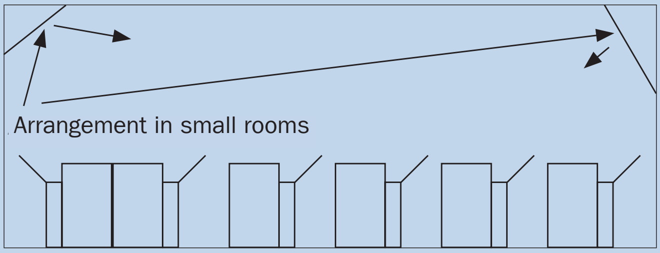
- Absorbers on the rear and side walls can be left out if, in turn, the entire ceiling surface is designed with absorbing features.
- Reflectors can be left out due to the small distance.

Lecture halls with a large number of people often have little need for additional absorption in the high frequency range. For this reason, the use of acoustic systems with sufficient degree of sound absorption is appropriate mainly in the low frequency range.

Arrangement of sound absorption



Positioning of reflectors



Note:

High absorption does not necessarily have the effect of a better acoustic quality or intelligibility. In fact, the absorption of space-limiting surfaces shall be harmonised with the desirable reverberation time, as well as furnishings and the number of people.

SOUND ABSORPTION
IN THE LABORATORY

The measurement is performed in a so-called reverberation room. This room is equipped with diffusers and reflectors such that a diffuse sound field results.

Measuring procedure and room characteristics are standardised worldwide according to DIN EN ISO 354. The sound absorption is determined in three steps:

- Measuring the reverberation time in the empty room
- Measuring the reverberation time with test specimen
- Calculating the absorption from the difference of the two measurements

The sound absorption is calculated on the basis of the Sabine equation because the diffusion given is optimal – and the reverberation time is changed only through the test specimen.

Note: The test specimen is usually located on the floor, no matter whether it is a wall or ceiling cladding, or flooring. This facilitates the installation and has no impact on the measured value.

Our data sheets
for sound absorption
are available online at
www.vogl-ceilingsystems.com

ABSORPTION MEASUREMENT

SOUND ABSORPTION
IN CONSTRUCTION WORK

The reverberation time is measured according to DIN EN ISO 3382 “Measuring of reverberation time in rooms with reference to other acoustic parameters”. The total absorption in the room can be calculated from the measured reverberation time. However, the absorption coefficient of each of the partial areas can only be roughly estimated. There are three reasons for that:

- Within a room, there are numerous different kinds of surfaces, i.e., the determination of the absorption of a specific surface area requires that the absorption of all other surfaces is either negligibly small, or sufficiently well-known (which is actually often the case in practice!).
- The sound field is not sufficiently diffuse. Often enough, one room direction (ceiling – floor) is much more strongly damped than the others, i.e., an even distribution of the absorption is not ensured. This can result in significant inaccuracy.
- The reverberation time is measured according to DIN EN ISO 3382 in the ready-for-use state (with or without people). Yet the absorption of the furnishings is usually neither negligibly small nor sufficiently known. If the measurements are carried out in an (almost) empty room (which is often the case in practice), the problem is mostly associated with insufficient diffusivity.

The right acoustics for each application – conduct your individual acoustic calculations according to DIN 18041, ÖNORM B 8115-3 or Arrêté du 25 avril with the Vogl acoustic calculation tool!

Whether classroom, theatre or exhibition hall – the tool derives the design parameters, tolerance ranges and limits by using the applicable standard.

This makes it quick and easy for you to find the suitable Vogl product for every project. Find the convenient online tool under:

www.vogl-akustiker.de

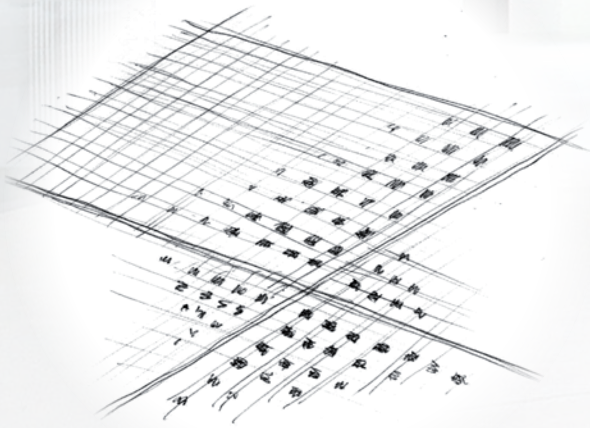
Optimisation

of room acoustics by means of

PLANAR ACOUSTIC DESIGN CEILINGS

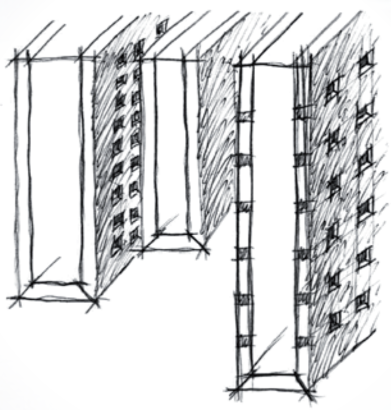
Acoustic design ceilings have to meet the highest demands in terms of performance and aesthetics in drywall construction. Particularly in highly frequented areas, such ceiling systems serve as sound absorbers, cooling elements and eye catchers at the same time. For this reason, high precision in installation is particularly needed here. Since, unlike grid-based ceiling solutions, errors in the installation are immediately visible in the finished product and seriously affect the final appearance.

With the help of the acoustic design ceilings in the VoglFuge system, a high degree of reliability during installation and with regard to the final result is guaranteed.



BAFFLES & LAMELLAE

The bending and folding techniques in drywall construction offer an abundance of creative design possibilities.
These manufacturing technologies can also be used for pre-fabrication of high-precision lamellae or baffles. In combination with commercially available drywall profiles as well as connecting elements and suspended brackets, a uniform system made of perforated surface and verified suspension is created.
Baffles and lamellae – exactly as floating ceilings too – offer a design possibility of a ceiling structure without having to completely close the ceiling surface.



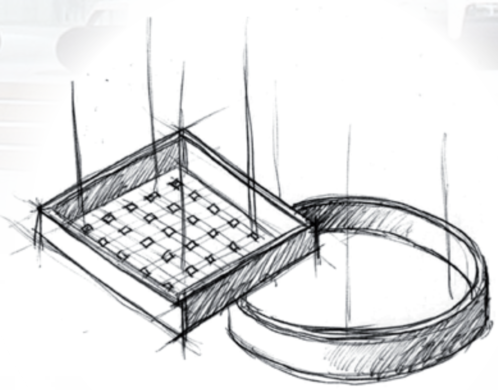
To make sure that the sound field created is as diffuse as possible in order to prevent flutter echoes, different elements on the ceiling, on the walls or on the floor as well as within room furnishings can be used. We offer an abundance of products and customised moulded components to optimise the room acoustics in your project.

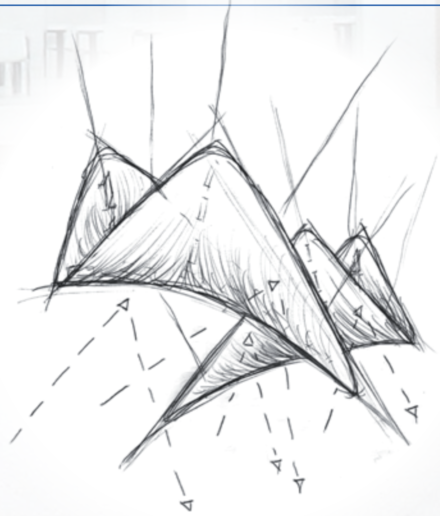
INDIVIDUAL FLOATING CEILINGS

Floating ceilings lastingly enhance any conventional ceiling construction.
The ceilings with a perforated design and with acoustic support improve the reverberation time in both new and already existing building projects. This way, they selectively contribute to improved room acoustics.
The level of pre-fabrication determines the processes required on-site during installation – supported by a simple assembly technique with commercially available ceiling framework components to ensure easy handling and particularly quick processing at the construction site.

REFLECTING CEILING ELEMENTS

Depending on the room situation, in addition to absorbing materials, some reflecting surfaces have to be positioned within the room structure. In doing so, an adequate diffuse sound field shall be considered, and the sound absorption in the room as well as speech intelligibility in combination with other parameters shall be observed. For this purpose, reflecting ceiling components can be made by means of stepwise glued plasterboards in order to achieve greater mass per unit area. In addition to this, customised moulded components made of gypsum plasterboards or fibre-reinforced gypsum can be used as reflecting elements in the interior design.





SOUND ABSORPTION

with Vogl Ceilingsystems

Acoustic design ceilings

Perforation pattern	Structure	Perforated area	Acoustic support / damping	αp 125 Hz	αp 250 Hz	αp 500 Hz	αp 1,000 Hz	αp 2,000 Hz	αp 4,000 Hz	αw	NRC	Absorption class
Acoustic design panels, continuous perforation												
6/18R	65 mm	8.7 %	/	0.15	0.25	0.45	0.60	0.50	0.40	0.50	0.45	D
	65 mm	8.7 %	30 mm (SSP1)	0.30	0.45	0.50	0.55	0.50	0.50	0.55	0.50	D
	100 mm	8.7 %	/	0.20	0.45	0.60	0.60	0.50	0.45	0.55	0.55	D
	100 mm	8.7 %	30 mm (SSP1)	0.35	0.55	0.60	0.60	0.50	0.50	0.60	0.55	C
	200 mm	8.7 %	/	0.35	0.45	0.55	0.55	0.50	0.50	0.55	0.50	D
	200 mm	8.7 %	30 mm (SSP1)	0.40	0.50	0.55	0.55	0.55	0.55	0.55	0.55	D
	400 mm	8.7 %	/	0.40	0.55	0.55	0.55	0.55	0.50	0.55	0.55	D
	400 mm	8.7 %	30 mm (SSP1)	0.40	0.55	0.55	0.60	0.60	0.55	0.60	0.55	C
8/18R	65 mm	15.5 %	/	0.10	0.25	0.60	0.80	0.70	0.55	0.55 (M)	0.60	D
	65 mm	15.5 %	30 mm (SSP1)	0.25	0.50	0.70	0.80	0.75	0.65	0.75	0.70	C
	100 mm	15.5 %	/	0.20	0.50	0.75	0.80	0.60	0.60	0.70	0.65	C
	100 mm	15.5 %	30 mm (SSP1)	0.30	0.70	0.80	0.80	0.70	0.65	0.75	0.75	C
	200 mm	15.5 %	/	0.35	0.60	0.75	0.70	0.65	0.65	0.70	0.65	C
	200 mm	15.5 %	30 mm (SSP1)	0.40	0.65	0.75	0.75	0.75	0.75	0.75	0.70	C
	400 mm	15.5 %	/	0.50	0.70	0.65	0.80	0.65	0.65	0.70	0.65	C
	400 mm	15.5 %	30 mm (SSP1)	0.50	0.65	0.70	0.80	0.75	0.75	0.75	0.70	C
10/23R	65 mm	14.8 %	/	0.10	0.25	0.60	0.70	0.70	0.55	0.55	0.60	D
	65 mm	14.8 %	30 mm (SSP1)	0.25	0.45	0.65	0.70	0.65	0.65	0.65	0.60	C
	100 mm	14.8 %	/	0.20	0.50	0.75	0,80	0.60	0.55	0.65	0.65	C
	100 mm	14.8 %	30 mm (SSP1)	0.30	0.65	0.80	0,75	0.70	0.65	0.75	0.75	C
	200 mm	14.8 %	/	0.35	0.55	0.75	0.65	0.65	0.60	0.70	0.65	C
	200 mm	14.8 %	30 mm (SSP1)	0.40	0.60	0.70	0.70	0.70	0.70	0.70	0.70	C
	400 mm	14.8 %	/	0.50	0.70	0.65	0.70	0.65	0.60	0.70	0.65	C
	400 mm	14.8 %	30 mm (SSP1)	0.50	0.65	0.70	0.80	0.75	0.70	0.75	0.70	C
12/25R	65 mm	18.1 %	/	0.10	0.25	0.60	0.80	0.75	0.50	0.55 (M)	0.60	D
	65 mm	18.1 %	30 mm (SSP1)	0.20	0.45	0.70	0.75	0.80	0.60	0.70	0.70	C
	100 mm	18.1 %	/	0.20	0.50	0.75	0.85	0.65	0.55	0.70	0.70	C
	100 mm	18.1 %	30 mm (SSP1)	0.30	0.80	0.85	0.85	0.75	0.65	0.80	0.80	B
	200 mm	18.1 %	/	0.35	0.60	0.80	0.70	0.70	0.60	0.70	0.70	C
	200 mm	18.1 %	30 mm (SSP1)	0.40	0.65	0.75	0.75	0.80	0.75	0.80	0.75	B
	400 mm	18.1 %	/	0.50	0.75	0.65	0.70	0.70	0.60	0.70 (L)	0.70	C
	400 mm	18.1 %	30 mm (SSP1)	0.50	0.70	0.70	0.85	0.80	0.75	0.80	0.75	B
15/30R	65 mm	19.6 %	/	0.10	0.25	0.60	0.85	0.65	0.60	0.55 (M)	0.60	D
	65 mm	19.6 %	30 mm (SSP1)	0.20	0.50	0.75	0.80	0.70	0.70	0.75	0.70	C
	100 mm	19.6 %	/	0.20	0.50	0.75	0.85	0.65	0.55	0.70	0.70	C
	100 mm	19.6 %	30 mm (SSP1)	0.30	0.70	0.90	0.85	0.80	0.70	0.85	0.80	B
	200 mm	19.6 %	/	0.35	0.60	0.80	0.75	0.65	0.65	0.75	0.70	C
	200 mm	19.6 %	30 mm (SSP1)	0.40	0.70	0.80	0.80	0.80	0.75	0.80	0.75	B
	400 mm	19.6 %	/	0.50	0.75	0.70	0.75	0.65	0.60	0.70 (L)	0.70	C
	400 mm	19.6 %	30 mm (SSP1)	0.50	0.75	0.75	0.85	0.85	0.75	0.85	0.75	B
20/42R	200 mm	17.8 %	/	0.25	0.65	0.80	0.65	0.50	0.55	0.60 (L)	0.65	C
	200 mm	17.8 %	30 mm (SSP1)	0.35	0.70	0.80	0.80	0.70	0.65	0.75	0.80	C
8/12/50R	65 mm	13.1 %	/	0.10	0.25	0.60	0.70	0.65	0.45	0.55	0.55	D
	65 mm	13.1 %	30 mm (SSP1)	0.25	0.45	0.70	0.70	0.70	0.55	0.70	0.65	C
	100 mm	13.1 %	/	0.20	0.50	0.70	0.75	0.55	0.50	0.60	0.65	C
	100 mm	13.1 %	30 mm (SSP1)	0.30	0.65	0.75	0.75	0.65	0.55	0.70	0.70	C
	200 mm	13.1 %	/	0.35	0.55	0.70	0.65	0.60	0.55	0.65	0.60	C
	200 mm	13.1 %	30 mm (SSP1)	0.40	0.60	0.70	0.70	0.70	0.65	0.70	0.65	C
	400 mm	13.1 %	/	0.45	0.60	0.60	0.60	0.50	0.45	0.55 (L)	0.55	D
	400 mm	13.1 %	30 mm (SSP1)	0.40	0.55	0.60	0.65	0.55	0.50	0.60	0.55	C
12/20/66R	65 mm	19.6 %	/	0.05	0.25	0.55	0.85	0.65	0,55	0.55 (M)	0.60	D
	65 mm	19.6 %	30 mm (SSP1)	0.20	0.50	0.70	0.80	0.70	0,70	0.70	0.70	C
	100 mm	19.6 %	/	0.20	0.50	0.75	0.85	0.55	0,60	0.65	0.65	C
	100 mm	19.6 %	30 mm (SSP1)	0.30	0.70	0.85	0.85	0.75	0,70	0.80	0.80	B
	200 mm	19.6 %	/	0.35	0.60	0.80	0.75	0.60	0,65	0.70	0.70	C
	200 mm	19.6 %	30 mm (SSP1)	0.40	0.70	0.80	0.80	0.75	0,75	0.80	0.75	B
	400 mm	19.6 %	/	0.50	0.75	0.70	0.75	0.60	0,60	0.70 (L)	0.65	C
	400 mm	19.6 %	30 mm (SSP1)	0.50	0.70	0.70	0.85	0.80	0,75	0.80	0.75	B

Acoustic design ceilings

Acoustic design panels, continuous perforation												
Perforation pattern	Structure	Perforated area	Acoustic support / damping	α_p 125 Hz	α_p 250 Kz	α_p 500 Hz	α_p 1,000 Hz	α_p 2,000 Hz	α_p 4,000 Hz	α_w	NRC	Absorption class
8/18Q	65 mm	19.8 %	/	0.05	0.25	0.60	0.85	0.75	0.60	0.55 (M)	0.60	D
	65 mm	19.8 %	30 mm (SSP1)	0.20	0.50	0.80	0.80	0.75	0.75	0.75	0.70	C
	100 mm	19.8 %	/	0.15	0.45	0.80	0.85	0.65	0.65	0.70	0.70	C
	100 mm	19.8 %	30 mm (SSP1)	0.30	0.70	0.90	0.90	0.80	0.75	0.85	0.85	B
	200 mm	19.8 %	/	0.35	0.65	0.85	0.75	0.70	0.70	0.75	0.70	C
	200 mm	19.8 %	30 mm (SSP1)	0.40	0.70	0.85	0.80	0.85	0.85	0.85	0.80	B
	400 mm	19.8 %	/	0.50	0.75	0.70	0.75	0.70	0.65	0.75	0.70	C
	400 mm	19.8 %	30 mm (SSP1)	0.50	0.75	0.75	0.90	0.85	0.80	0.85	0.80	B
12/25Q	65 mm	23.0 %	/	0.05	0.25	0.55	0.75	0.75	0.55	0.55	0.60	D
	65 mm	23.0 %	30 mm (SSP1)	0.20	0.50	0.80	0.90	0.80	0.70	0.80	0.75	B
	100 mm	23.0 %	/	0.15	0.45	0.75	0.90	0.70	0.60	0.70	0.70	C
	100 mm	23.0 %	30 mm (SSP1)	0.30	0.70	0.90	0.90	0.85	0.75	0.90	0.85	A
	200 mm	23.0 %	/	0.35	0.65	0.85	0.75	0.70	0.65	0.75	0.75	C
	200 mm	23.0 %	30 mm (SSP1)	0.40	0.70	0.85	0.85	0.90	0.85	0.90	0.85	A
	400 mm	23.0 %	/	0.50	0.75	0.70	0.75	0.75	0.65	0.75	0.70	C
	400 mm	23.0 %	30 mm (SSP1)	0.50	0.75	0.75	0.90	0.90	0.80	0.85	0.80	B
8/15/20R	65 mm	9.5 %	/	0.10	0.25	0.50	0.60	0.45	0.40	0.50	0.45	D
	65 mm	9.5 %	30 mm (SSP1)	0.30	0.40	0.55	0.55	0.50	0.40	0.55	0.50	D
	100 mm	9.5 %	/	0.20	0.50	0.65	0.65	0.45	0.40	0.50	0.55	D
	100 mm	9.5 %	30 mm (SSP1)	0.35	0.60	0.65	0.60	0.45	0.40	0.50 (L)	0.60	D
	200 mm	9.5 %	/	0.35	0.50	0.60	0.55	0.45	0.45	0.55	0.50	D
	200 mm	9.5 %	30 mm (SSP1)	0.40	0.50	0.60	0.55	0.55	0.50	0.60	0.55	C
	400 mm	9.5 %	/	0.50	0.65	0.65	0.65	0.60	0.55	0.65	0.65	C
	400 mm	9.5 %	30 mm (SSP1)	0.45	0.65	0.65	0.75	0.70	0.60	0.70	0.65	C
10/16/22R	65 mm	12.6 %	/	0.10	0.30	0.60	0.75	0.55	0.45	0.55	0.55	D
	65 mm	12.6 %	30 mm (SSP1)	0.25	0.55	0.70	0.65	0.50	0.45	0.55	0.60	D
	100 mm	12.6 %	/	0.20	0.50	0.70	0.75	0.50	0.50	0.60	0.60	C
	100 mm	12.6 %	30 mm (SSP1)	0.30	0.60	0.65	0.60	0.50	0.45	0.55 (L)	0.60	D
	200 mm	12.6 %	/	0.35	0.60	0.70	0.65	0.50	0.50	0.60	0.60	C
	200 mm	12.6 %	30 mm (SSP1)	0.40	0.65	0.70	0.70	0.65	0.60	0.70	0.65	C
	400 mm	12.6 %	/	0.45	0.65	0.65	0.65	0.55	0.55	0.65	0.60	C
	400 mm	12.6 %	30 mm (SSP1)	0.45	0.60	0.60	0.70	0.65	0.60	0.65	0.65	C
12/20/35R	65 mm	11.0 %	/	0.10	0.25	0.55	0.60	0.45	0.40	0.50	0.45	D
	65 mm	11.0 %	30 mm (SSP1)	0.30	0.45	0.65	0.60	0.50	0.40	0.55	0.55	D
	100 mm	11.0 %	/	0.20	0.50	0.70	0.65	0.40	0.35	0.45 (LM)	0.55	D
	100 mm	11.0 %	30 mm (SSP1)	0.30	0.60	0.70	0.65	0.50	0.40	0.55 (L)	0.60	D
	200 mm	11.0 %	/	0.35	0.50	0.65	0.55	0.45	0.45	0.55	0.55	D
	200 mm	11.0 %	30 mm (SSP1)	0.40	0.55	0.65	0.60	0.55	0.50	0.60	0.55	C
	400 mm	11.0 %	/	0.45	0.65	0.60	0.60	0.45	0.40	0.50 (L)	0.55	D
	400 mm	11.0 %	30 mm (SSP1)	0.45	0.60	0.60	0.65	0.55	0.50	0.60	0.60	C

Acoustic design ceilings, block and slotted perforations												
Perforation pattern	Structure	Perforated area	Acoustic support / damping	α_p 125 Hz	α_p 250 Hz	α_p 500 Hz	α_p 1,000 Hz	α_p 2,000 Hz	α_p 4,000 Hz	α_w	NRC	Absorption class
8/18R Design 4F	200 mm	12.9 %	/	0.30	0.60	0.75	0.60	0.55	0.50	0.60	0.60	C
	200 mm	12.9 %	30 mm (SSP1)	0.35	0.60	0.70	0.70	0.65	0.60	0.70	0.65	C
8/18R Design 8F	200 mm	12.1 %	/	0.30	0.55	0.70	0.60	0.55	0.50	0.60	0.60	C
	200 mm	12.1 %	30 mm (SSP1)	0.35	0.60	0.70	0.65	0.65	0.55	0.65	0.65	C
8/18R Design 32F	200 mm	9.1 %	/	0.30	0.50	0.60	0.50	0.45	0.40	0.50	0.50	D
	200 mm	9.1 %	30 mm (SSP1)	0.35	0.50	0.60	0.55	0.50	0.50	0.65	0.65	C
12/25R Design 4F	200 mm	14.9 %	/	0.30	0.60	0.75	0.65	0.55	0.45	0.60	0.65	C
	200 mm	14.9 %	30 mm (SSP1)	0.35	0.65	0.75	0.70	0.70	0.60	0.70	0.70	C
12/25R Design 8F	200 mm	13.9 %	/	0.30	0.60	0.75	0.65	0.55	0.45	0.60	0.60	C
	200 mm	13.9 %	30 mm (SSP1)	0.35	0.60	0.70	0.70	0.65	0.55	0.70	0.65	C
12/25R Design 32F	200 mm	10.2 %	/	0.30	0.50	0.65	0.55	0.45	0.35	0.50	0.55	D
	200 mm	10.2 %	30 mm (SSP1)	0.35	0.50	0.60	0.55	0.55	0.45	0.55	0.55	D

Acoustic design ceilings, block and slotted perforations												
Perforation pattern	Structure	Perforated area	Acoustic support / damping	αp 125 Hz	αp 250 Hz	αp 500 Hz	αp 1,000 Hz	αp 2,000 Hz	αp 4,000 Hz	αw	NRC	Absorption class
12/25Q Design 4F	200 mm	18.9 %	/	0.30	0.65	0.85	0.70	0.65	0.75	0.70	0.70	C
	200 mm	18.9 %	30 mm (SSP1)	0.35	0.70	0.85	0.80	0.85	0.90	0.85	0.80	B
12/25Q Design 8F	200 mm	17.7 %	/	0.30	0.65	0.80	0.70	0.65	0.70	0.70	0.70	C
	200 mm	17.7 %	30 mm (SSP1)	0.35	0.70	0.80	0.75	0.80	0.85	0.80	0.75	B
12/25Q Design 32F	200 mm	13.0 %	/	0.30	0.65	0.75	0.60	0.55	0.55	0.60 (L)	0.65	C
	200 mm	13.0 %	30 mm (SSP1)	0.35	0.65	0.70	0.65	0.65	0.75	0.70	0.70	C
5/82/15,4SL Design 4F	200 mm	15.7 %	/	0.30	0.60	0.75	0.60	0.50	0.45	0.55 (L)	0.60	D
	200 mm	15.7 %	30 mm (SSP1)	0.35	0.65	0.70	0.65	0.65	0.55	0.65	0.65	C
5/82/15,4SL Design 8F	200 mm	13.7 %	/	0.30	0.60	0.70	0.55	0.45	0.40	0.50 (L)	0.55	D
	200 mm	13.7 %	30 mm (SSP1)	0.35	0.60	0.65	0.60	0.55	0.50	0.65	0.65	C
5/82/15,4SL Design 8/16F	200 mm	10.9 %	/	0.30	0.55	0.65	0.50	0.40	0.35	0.45 (L)	0.50	D
	200 mm	10.9 %	30 mm (SSP1)	0.35	0.55	0.60	0.55	0.50	0.45	0.55	0.55	D

Acoustic plaster system **Vogl**Toptec

Akustikputzdecken Toptec												
Perforation pattern	Structure	Perforated area	Acoustic support / damping	αp 125 Hz	αp 250 Hz	αp 500 Hz	αp 1,000 Hz	αp 2,000 Hz	αp 4,000 Hz	αw	NRC	Absorption class
Reflexio (glatt)	200 mm	0 %	/	0.10	0.05	0.05	0.05	0.10	0.20	0.10	0.05	/
	200 mm	0 %	30 mm (SSP1)	0.15	0.10	0.05	0.10	0.15	0.30	0.10 (H)	0.10	/
8/18R	65 mm	15.4 %	/	0.10	0.35	0.60	0.75	0.65	0.55	0.60	0.60	C
	65 mm	15.4 %	30 mm (SSP1)	0.25	0.60	0.75	0.75	0.65	0.65	0.75	0.70	C
	100 mm	15.4 %	/	0.20	0.50	0.70	0.75	0.60	0.65	0.70	0.65	C
	100 mm	15.4 %	30 mm (SSP1)	0.30	0.65	0.75	0.75	0.65	0.70	0.75	0.70	C
	200 mm	15.4 %	/	0.35	0.65	0.75	0.65	0.65	0.70	0.70	0.65	C
	200 mm	15.4 %	30 mm (SSP1)	0.45	0.75	0.75	0.75	0.75	0.75	0.75	0.75	C
	400 mm	15.4 %	/	0.45	0.65	0.65	0.65	0.65	0.70	0.65	0.65	C
	400 mm	15.4 %	30 mm (SSP1)	0.45	0.60	0.65	0.75	0.75	0.75	0.75	0.70	C
12/25Q	65 mm	22.9 %	/	0.10	0.30	0.60	0.85	0.75	0.60	0.60 (M)	0.65	C
	65 mm	22.9 %	30 mm (SSP1)	0.25	0.60	0.85	0.90	0.75	0.70	0.80	0.80	B
	100 mm	22.9 %	/	0.20	0.50	0.75	0.85	0.70	0.65	0.75	0.70	C
	100 mm	22.9 %	30 mm (SSP1)	0.30	0.70	0.85	0.85	0.80	0.75	0.85	0.80	B
	200 mm	22.9 %	/	0.35	0.70	0.85	0.70	0.70	0.75	0.75	0.70	C
	200 mm	22.9 %	30 mm (SSP1)	0.45	0.80	0.85	0.85	0.90	0.90	0.90	0.85	A
	400 mm	22.9 %	/	0.50	0.75	0.70	0.75	0.75	0.70	0.75	0.70	C
	400 mm	22.9 %	30 mm (SSP1)	0.50	0.70	0.70	0.85	0.85	0.80	0.80	0.75	B
12/25R DLV (Ultrakustik)	65 mm	33.9 %	/	0.05	0.25	0.55	0.85	0.85	0.70	0.55 (MH)	0.65	D
	65 mm	33.9 %	30 mm (SSP1)	0.20	0.60	0.90	1.00	0.90	0.85	0.90	0.85	A
	100 mm	33.9 %	/	0.15	0.45	0.80	0.90	0.75	0.80	0.75	0.70	C
	100 mm	33.9 %	30 mm (SSP1)	0.30	0.75	0.95	0.95	0.90	0.90	0.95	0.90	A
	200 mm	33.9 %	/	0.30	0.65	0.85	0.75	0.75	0.85	0.80	0.75	B
	200 mm	33.9 %	30 mm (SSP1)	0.45	0.80	0.90	0.90	1.00	1.00	0.95	0.90	A
	400 mm	33.9 %	/	0.50	0.75	0.70	0.80	0.80	0.85	0.80	0.75	B
	400 mm	33.9 %	30 mm (SSP1)	0.55	0.80	0.80	0.95	1.00	0.95	0.90	0.85	A

Ceiling tiles

Perforation pattern	Structure	Perforated area	Acoustic support / damping	αp 125 Hz	αp 250 Hz	αp 500 Hz	αp 1,000 Hz	αp 2,000 Hz	αp 4,000 Hz	αw	NRC	Absorption class
Ceiling tiles												
6/15R	200 mm	9.6 - 10.7 % (*)	/	0.30	0.60	0.70	0.60	0.55	0.45	0.60	0.60	C
	200 mm	9.6 - 10.7 % (*)	30 mm (SSP1)	0.35	0.65	0.70	0.70	0.65	0.55	0.70	0.70	C
6/18R	200 mm	6.5 - 7.5 % (*)	/	0.25	0.50	0.60	0.50	0.45	0.40	0.50	0.50	D
	200 mm	6.5 - 7.5 % (*)	30 mm (SSP1)	0.35	0.55	0.55	0.55	0.50	0.45	0.55	0.50	D
	400 mm	6.5 - 7.4 % (*)	/	0.40	0.50	0.50	0.50	0.45	0,40	0.50	0.50	D
	400 mm	6.5 - 7.4 % (*)	30 mm (SSP1)	0.40	0.50	0.55	0.60	0.50	0.45	0.55	0.50	D
8/18R	200 mm	11.4 - 13.0 % (*)	/	0.30	0.60	0.75	0.65	0.60	0.55	0.65	0.65	C
	200 mm	11.4 - 13.0 % (*)	30 mm (SSP1)	0.40	0.65	0.70	0.70	0.65	0.65	0.70	0.65	C
	400 mm	11.4 - 13.0 % (*)	/	0.45	0.60	0.60	0.65	0.60	0.60	0.65	0.60	C
	400 mm	11.4 - 13.0 % (*)	30 mm (SSP1)	0.45	0.60	0.65	0.75	0.70	0.65	0.70	0.65	C
12/20/66R	200 mm	12.4 - 18.1 % (*)	/	0.30	0.70	0.85	0.65	0.55	0.55	0.65 (L)	0.65	C
	200 mm	12.4 - 18.1 % (*)	30 mm (SSP1)	0.35	0.70	0.80	0.80	0.75	0.65	0.80	0.75	B
	400 mm	12.4 - 18.1 % (*)	/	0.45	0.70	0.65	0.65	0.60	0.55	0.65 (L)	0.65	C
	400 mm	12.4 - 18.1 % (*)	30 mm (SSP1)	0.50	0.65	0.70	0.85	0.75	0.70	0.75	0.75	C
8/15/20R	200 mm	7.6 - 8.4 % (*)	/	0.30	0.55	0.60	0.55	0.40	0.35	0.45 (L)	0.50	D
	200 mm	7.6 - 8.4 % (*)	30 mm (SSP1)	0.35	0.55	0.55	0.55	0.50	0.45	0.55	0.55	D
3,5/9Q	200 mm	10.2 - 12.9 % (*)	/	0.30	0.65	0.75	0.65	0.60	0.50	0.65	0.70	C
	200 mm	10.2 - 12.9 % (*)	30 mm (SSP1)	0.40	0.70	0.75	0.75	0.70	0.65	0.75	0.70	C
	200 mm	10.2 - 12.9 % (*)	50 mm (SSP2)	0.45	0.65	0.65	0.75	0.70	0.60	0.70	0.70	C
	400 mm	10.2 - 12.9 % (*)	/	0.45	0.65	0.65	0.65	0.60	0.55	0.65	0.65	C
	400 mm	10.2 - 12.9 % (*)	30 mm (SSP1)	0.45	0.65	0.65	0.75	0.75	0.70	0.75	0.70	C
	400 mm	10.2 - 12.9 % (*)	50 mm (SSP2)	0.45	0.65	0.80	0.75	0.70	0.65	0.75	0.70	C
8/18Q	200 mm	14.5 - 16.9 % (*)	/	0.30	0.65	0.80	0.70	0.65	0.60	0.70	0.65	C
	200 mm	14.5 - 16.9 % (*)	30 mm (SSP1)	0.35	0.70	0.80	0.75	0.75	0.70	0.80	0.75	B
	400 mm	14.5 - 16.9 % (*)	/	0.45	0.70	0.65	0.70	0.65	0.65	0.70	0.65	C
	400 mm	14.5 - 16.9 % (*)	30 mm (SSP1)	0.45	0.65	0.70	0.80	0.80	0.75	0.80	0.70	B
12/25Q	200 mm	17.1 - 20.5 % (*)	/	0.30	0.65	0.85	0.70	0.65	0.60	0.70	0.70	C
	200 mm	17.1 - 20.5 % (*)	30 mm (SSP1)	0.35	0.70	0.80	0.80	0.85	0.75	0.85	0.75	B
	400 mm	17.1 - 20.5 % (*)	/	0.45	0.80	0.70	0.70	0.70	0.65	0.70 (L)	0.70	C
	400 mm	17.1 - 20.5 % (*)	30 mm (SSP1)	0.50	0.65	0.70	0.85	0.85	0.75	0.80	0.75	B
5/82/15,4SL Design 16F	200 mm	10.1 - 11.5 % (*)	/	0.30	0.65	0.70	0.55	0.45	0.40	0.50 (L)	0.55	D
	200 mm	10.1 - 11.5 % (*)	30 mm (SSP1)	0.35	0.65	0.65	0.60	0.50	0.45	0.55 (L)	0.60	D
	400 mm	10.1 - 11.5 % (*)	/	0.45	0.65	0.60	0.55	0.45	0.40	0.50 (L)	0.55	D
	400 mm	10.1 - 11.5 % (*)	30 mm (SSP1)	0.45	0.60	0.60	0.65	0.55	0.50	0.60	0.60	C
12/25R DLV (Ultrakustik)	200 mm	27.7 - 29.4 % (*)	/	0.30	0.80	0.90	0.70	0.65	0.55	0.70	0.75	C
	200 mm	27.7 - 29.4 % (*)	30 mm (SSP1)	0.40	0.80	0.90	0.85	0.90	0.80	0.90	0.90	A
4/14/10 Oval	200 mm	19.9 - 24.0 % (*)	/	0.30	0.70	0.85	0.70	0.70	0.70	0.60 (LM)	0.75	C
	200 mm	19.9 - 24.0 % (*)	30 mm (SSP1)	0.40	0.75	0.85	0.85	0.90	0.90	0.90	0.85	A

(*) = varies by size and edge type

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