# The Pannello collection

## Fundamental principles of acoustics

**Acoustics and interior space**
As a sub-department of acoustics, spatial acoustics is concerned with the acoustic effects of tones, sounds, noises and other disturbances in limited spatial areas. In practical terms, the conclusions relating to noise insulation are of particular significance when it is a matter of counteracting negative acoustic conditions arising from architectural properties or the properties of interior design in enclosed spaces.

In our times the general acoustic level has increased many times over, partly through the increasing use of loud machines and partly as a result of the use of highly reflective materials. The acoustic insulation of interiors has thus become a factor of increasing importance. The object of insulation is to lower the general acoustic level in interior spaces that are designed on a large scale and suffer from excessive noise. The reasoning behind this is simple: from a certain level upward, noise is experienced by human beings as stressful, and a room becomes unpleasant to be in. The performance of working people decreases when they are subjected to stress from noise.

But this matter is often simply overlooked. A fundamental problem of spatial acoustics consists in the fact that unfavourable acoustic conditions are seldom perceived directly. Consequently it is often the case that they are frequently just accepted, even over extended periods, or not recognised as a reason for sluggish performance. Conditions that are unfavourable to speaking and listening are a phenomenon frequently to be observed in many offices, sport halls and class rooms.

Measures to counteract noise are advisable when acoustic stress presents a danger to health. Such measures are also desirable in places where in the nature of things people's spending time there is associated with a certain amount of stress or anticipation. This is the case in open-plan offices, restaurants, reception areas, waiting rooms and halls where various activities are carried on, as in hotels, airports, railway stations, wellness centres, hospitals, schools and universities - as also in factory buildings, warehouses and sport halls of every kind.

To create an atmosphere that will be experienced as positive, appropriate hearing conditions must be provided for the use of any room. These can be defined on the one hand by objective measurements of the acoustic level and the types of noise that are found, and represented accordingly. But the way in which a space is experienced acoustically is also decisively dependent on individual expectations and habits, and the physical and psychological properties of the persons in question. The acoustic design of rooms, when aimed at making people feel good in noisy surroundings or enabling them to enjoy music, will therefore explicitly involve the individual characteristics and tendencies of the users of the rooms at a fundamental level.

Besides the purely acoustic aims of interior design, there are of course other factors to be taken into account in the choice of means. Here we may mention considerations relating to the optical and haptic properties of the materials, and other non-acoustic properties like the brand and durability of a product and its tendency to accumulate dirt. Financial and economic factors play a part as well.

**Improving spatial acoustics**

The acoustics of a room is always specific, and is affected by many factors, such as the shape of the room and the materials that have used on the floor, walls and ceiling. In order to counteract the unwanted propagation of sound, various measures have been tried out and others are currently being developed. A tried and tested method of noise abatement, in relation to the given spatial properties and the prescribed use of the room, consists in installing both noise-absorbing and noise-reflecting surfaces of appropriate size in suitable positions. 'Good' acoustics means that the spatial acoustic properties of a room are adequate to the use for which it is designed. The acoustic requirements of a concert hall are different from those of a telephone exchange.

**Possible measures**

In principle, any room can acoustically optimised with a view to the intended use. In the spatial acoustics planning process, the shape and size of the room are factors of equal importance with the selection and positioning of the furnishings and elements of the interior decor. If the architectural conditions are to be left untouched, in practice it is generally the case that the only course remaining is to modify the materials of the ceilings and walls. Ceiling panels and wall panels of a noise-absorbing material are particularly suitable for this purpose. These can be strategically used to determine the reverberation properties of a room.

With the help of special computer programs it is possible to obtain a detailed description of a room's acoustics. This description defines the ideal quantity, size and position of the noise-absorbing materials to be installed, in relation to the desired effect. Especially in connection with rooms that have high acoustic requirements, like concert halls, lecture theatres and meeting and conference rooms, such calculations are an essentially important factor if the ideal acoustic quality is to be achieved. In rooms with relatively modest requirements, on the other hand, it is possible to achieve good spatial acoustics just on the basis of relevant past experience.

**Acoustic standards in the EU**

German standards

The following standards are currently present, as applicable to Germany, with reference to spatial acoustic interior design.[1]:

- DIN 18041: Acoustic properties of small and medium-sized rooms, 2004
- VDI 2569: Noise abatement and acoustic design in the office, 1990
- DIN EN ISO 3382: Acoustic measurement of the reverberation properties of rooms, with reference to other acoustic parameters, 2000
- DIN EN ISO 354: Acoustic measurement of noise absorption in halls, 2003
- VDI 2720, part 2: Noise abatement in rooms based on screening, 1983
- VDI 3760: Calculation and measurement of the propagation of sound in the workplace, 1996

Standards within the EU

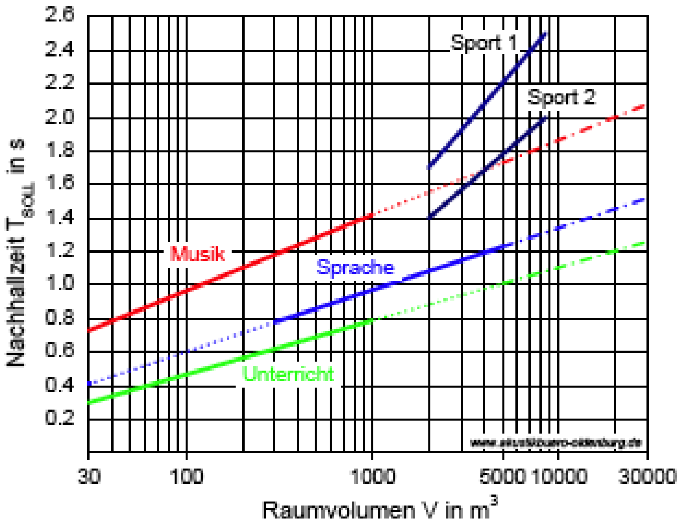
So far as the authors know, there are no unified prescriptions or recommendations relating to spatial acoustic design within the EU. The German standard DIN 18041, on the acoustic properties of small and medium-sized rooms, has no analogue in other countries. In terms of spatial acoustic requirements, there are thus no differences within the EU. The definition of key acoustic variables

[1] This list makes no claim to completeness.

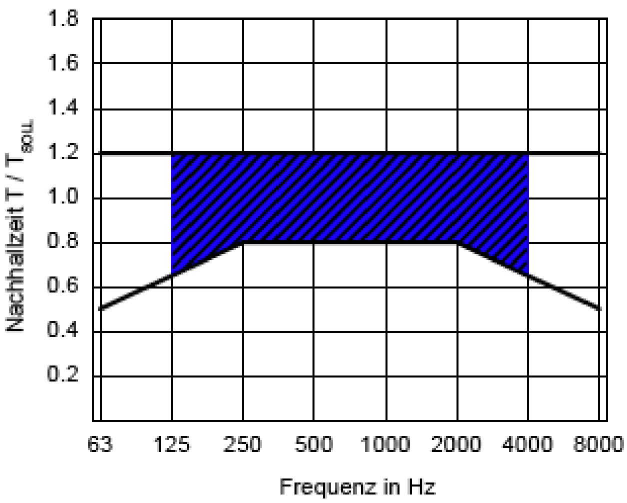
(e.g. DIN EN ISO 3382) and material properties (e.g. DIN EN ISO 354) is on the other hand internationally consistent based on unified standards.

**Spatial acoustic findings**

The following diagram shows a graphic from DIN 18041, which makes it possible to read off the recommended reverberation time at mean frequency in dependence on the volume of a room, for various different categories of use (speech, teaching and music). Example: a class room (teaching curve) with a volume of 200 cubic metres should have a mean reverberation time of 0.55 seconds.

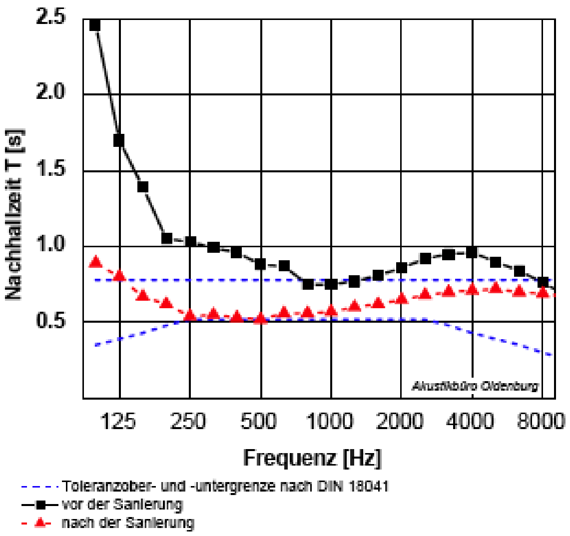



Besides the absolute value of the reverberation time, its dependence on frequency is also an important factor in acoustic perception. The following diagram shows, by way of example, the tolerance zone for optimised frequency of the reverberation time, based on DIN 18041's prescriptions for the spoken word.

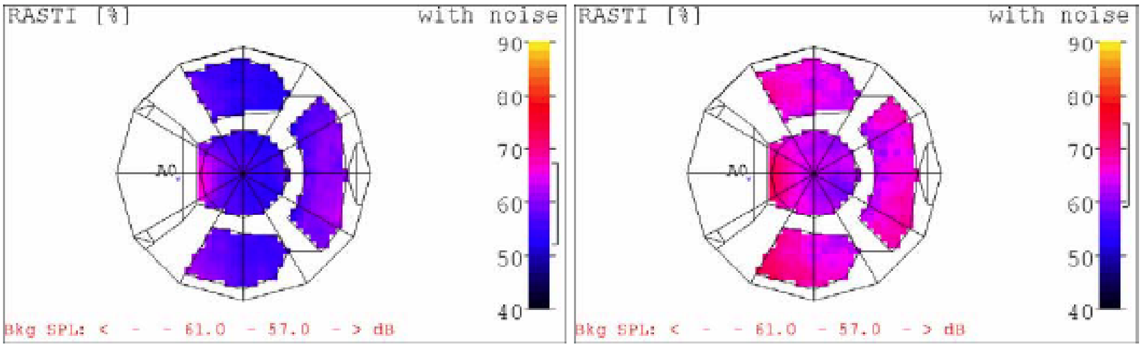



In view of the complexity of these matters and the many influencing factors involved, presentation of the data in tabular form would hardly be possible. It is possible however to represent a perfect room in terms of measurement technology.

There are many different possibilities available here. We show two below by way of example. The following graphic shows the results of the measurement of reverberation time in a classroom, before and after the optimisation of the spatial acoustic properties.




An alternative possibility of representing the spatial acoustics of a room is based on simulation involving three-dimensional models. The following graphic shows the RASTI value that results from a spatial acoustic simulation. The RASTI value stands for comprehensibility of the spoken word. The graphic on the left represents the situation before optimisation. Here good to very good values (RASTI 0.6 or more) were obtained at 24% of the places. After optimisation, as shown in the graphic on the right, good to very good RASTI values could be obtained at 99% of the places.



The wide range of alternatives for representing the acoustic properties extends as far as the auralisation of a room that is to be designed.

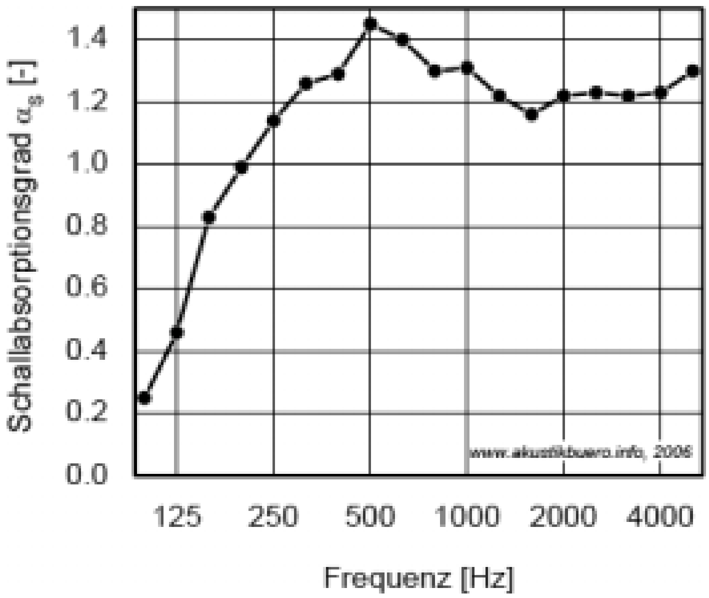
### Techniques for measuring spatial sound

The term 'spatial sound' is an unusual one. To determine the spatial acoustic properties of a room, generally the reverberation time, as defined by DIN EN ISO 3382, will be measured. Measurements are usually taken with the help of a special loudspeaker.

### Schematic representation: noise-absorption

These graphics serve to show sound absorption levels, as these are used in test reports. The following absorption curve of a wall panel is an example. As the sound absorption level of a material is a variable that depends on the frequency, there results a curve with individual measurement values varying between 100 Hz and 5000 Hz (as defined by DIN EN ISO 354).

Diagram Sound absorption coefficient of the Ruckstuhl wall panel

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