

Acoustical environment in open-space offices - How to achieve the field of confidence?

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Summery

The open-space office OPO has a sensitive acoustical behavior and therefore needs to be designed carefully. There is e.g. the disturbing noise, which arrives from adjacent working places. The falling off of noise-level with increasing distance should therefore be as big as possible. Instead rooms are often reverberant and noisy. Intelligibility of speech is too high and leads to a lack of concentration. Many sound reflections arrive from walls, from the ceiling, and the furniture and increase the disturbing sound. The Open-plan Office is a sensitive system with many parameters, which form an acoustical "Field of Confidence" FOC. This must be provided at every working-place. It includes the criteria of privacy, which are defined for different needs, and expectations such as for team-workers or single working places, a conference room or a more separated area for the head of department. In order to reach the Field of Confidence, background noise BGN is important and is introduced to mask interfering noise from adjacent places. BGN should be a non-informative noise, comparable with that of an air outlet, which is similar to a "Pink Noise" sound. The high steps of privacy mean Nr. IV, V or VI. They should be obtainable by a BGN as low as possible and a low interfering noise level underneath approx. 48 dB(A).

The acoustical design is focused on sound absorption. It is a challenge to arrange absorbing materials without overdamping the room or designing only small boxes. Desk orientations have to be considered as well as colours and optimal light luminances around the work places. This is the special duty of interior design. The environment should be inspiring and motivating as it is recommended with e.g. Feng-Shui design. The Field of Confidence needs acceptance.

In this paper the office environment is described with reference to existing OPO, which have been under acoustical control of IAB for many years. The paper deals with the different parameters and

their application in today's office design. Measurement results will be included, such as reverberation times, sound reflections, decrease of sound levels, and background noise levels. Evaluations will be made.

Field of Confidence

Since many years we have worked on open-plan offices to create an atmosphere of Privacy /1/2/. We have defined and introduced the "Field of Confidence" FOC, which is related to different parameters. Starting point is the desired and necessary privacy of each working place respectively. **Fig.1** marks the obtainable intelligibility of speech /3/4/5/ which should be as low as possible for good separation. A single working place needs, e.g. at least step III with a just sufficient separation equal to CIS=20% and the Signal to Noise ratio S/N of approx. 7dB(A). 7 dB(A) means that the disturbing speech level S is still 7dB above the background noise level N or BGN.

Step Privacy	Typ of Work	Separation	CIS %	S/N dB	AI %	STI
I		no	84	30	84	0,69
I/ II	Team Call C	no	73	20	56	0,54
III	Usual OPO	little	56	13	36	0,36
IV	Single place	just	20	7	8	0,16
V	Head of dep	better	10	3	2	0,12
VI	Secret place	good	<10	-3	<2	<0,12
VI	Single office	excellent	-	-10	-	-

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Fig.1 : Steps of privacy and speech intelligibility
CIS Common Intelligibility Scale, AI Articulation Index, STI Speech Transmission Index in accordance to DIN18041/8/ and DIN 60849/9/

In the same way, CIS, S/N, AI and STI are based on the difference between interfering noise S and the background noise level. The smaller the S/N ratio, the lower the speech intelligibility. Or: The smaller the S/N ratio, the better is the separation between adjacent working places. By reducing the level S often the BGL is reduced too. Then the

S/N stays constant, no improvement is reached. The sensitivity grows. The situation is even worse. The office is too quiet. This is outside the Field of Confidence.

Other fields of confidences are well known such as for light, temperature, and air velocity. They must be regarded likewise /11/. For OPO an essential step forward is the interior design, which obviously cannot be measured, instead it follows the latest inspirations and common style.

Maximum decrease of disturbing sound S

When a privat area is required with good separation of step V, the interfering noise S is 3 dB underneath the background noise N, BGN. How to reach this goal? Answer: By sound absorption and free-standing barriers. When a still higher separation is desired, a single office with deviding walls is of advantage with respect to privacy step VI and $S/N = -6$ dB. Maximum decrease is a significant characteristic of the office but unfortunately the most expensive one due to strict sound absorption and avoidance of sound reflections. Fig.2 shows the values for existing OPO in dB/a, the decrease of levels in dB (or dB(A)) per doubling the distance a. The value of 6 dB/a is obtainable under free-field conditions, similar to outdoor conditions without any sound reflection. Values below 6dB/a are very often obtained. In many cases values of more than 6 dB/a are required to lower the S level, e.g. Nr. 8, 9, 10. That is to say: A good office design is a predomination.

When sound travels across the office, its low, middle, and high frequencies have almost the same behaviour. That is to say, the values of table 1 are mean average values. In order to measure the decrease, an omni-directional sound source has been used to irradiate sound in all directions while an omni-directional microphone receives all room responses.

BGN as masking noise

It is known that BGN can mask the interfering noise. The smaller the S/N ratio the better the separation. When all measures are taken to reduce S, BGN must be increased. This is stated clearly in VDI 2569:1990:

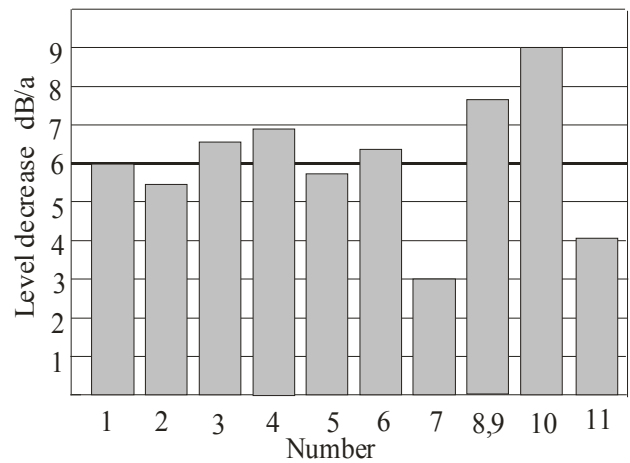


Fig. 2 Desired and existing decrease of sound level with doubling the distance

1 VDV 2569 office with loud speech / 2 as 1 low speech level/ 3 Call Center loud, hectic day/ 4 office 6 places/ 5 OPO with barriers/ 6 OPO with barriers/ 7 OPO team/ 8,9 OPO with barriers/ 10 very damped with barriers/ 11 as 3 quiet, normal day

Different decreases for OPO investigated by IAB in last months: A Campus/ B DBAG Frankfurt/ C single offices/ D for comparisons: VDI 2569 recommendation

“An artificial background noise may be introduced to mask interfering noise; by using uninformative steady noise produced by electro-acoustical installations with an increase of low frequencies similar to Pink Noise Sound.”

VDI proposes in table 3 a BGN of up to 45 dB(A). This is the masking noise, which has been suggested for many years, originally for more than 800 working places /10/. Once every year the authors control the levels and their frequency response as shown in Fig.3

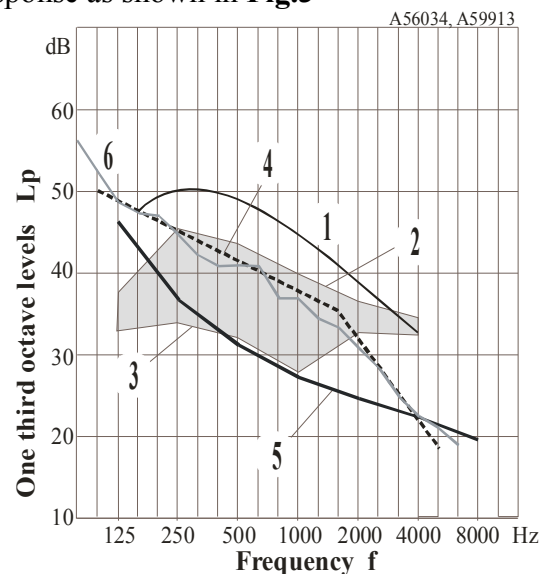
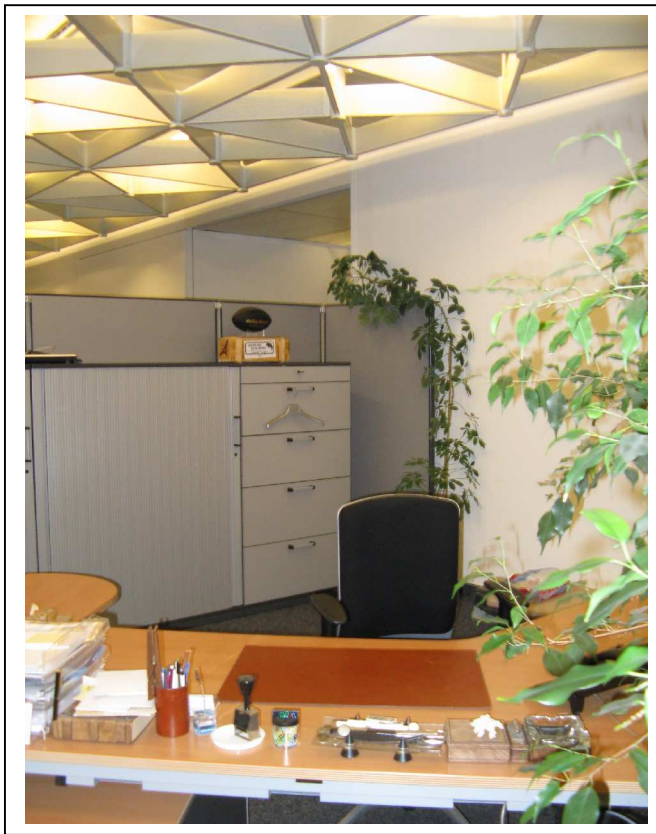


Fig.3 Interfering noise levels S and evaluations

1 Speech level in accordance to Ternoscy, 2 Campus on 5 positions, 3 as 2 minimum values, 4 Permitted for OPO in accordance to Völker 1970 45 dB(A), 5 Noise Rating Curve 37 dB(A), 6 as 2,3 last control in 2008

Fig.4 shows a view of OPO. Sound absorption is required for the wall, the capboard with perforated doors, for the free-standing barriers as well as the ceiling. The field of confidence is obtained.



Parameters as setscrews

The Field of Confidence is now obtainable by using the setscrews for interfering Noise S, for defining the step of privacy, and the S/N ratio and above all the BGN level. Fig. 5 describes this procedure.

Example 1: For the head of department the privacy should be at least step V with CIS=10% and AI=2% what is equal to a separation of “just good”. They are working places like Nr. 9 and 10 in Fig. 5. with an BGN of 47 dB(A). That requires a strict acoustical design to achieve a lowering of the arriving interfering noise from the neighborhood, here 44-46 dB(A). In order to reach these levels, strong discipline to lower voice is an alternative.

Example 2: A working place in a call center allows more interfering noise and therefore only little separation. The CIS value is CIS=56%, S/N=13 dB and AI=36%. The working place is Nr. 1 in Fig. 5 with a BGN=44 dB(A). The interfering noise S= 54 to 56 dB(A). That is much higher than in example 1. The separation is only little with poor intelligibility.

The area D in Fig.5 has S-levels between 50 and 57 dB(A). That is equal to quiet and loud speech in accordance with VDI recommendation VDI 2569.

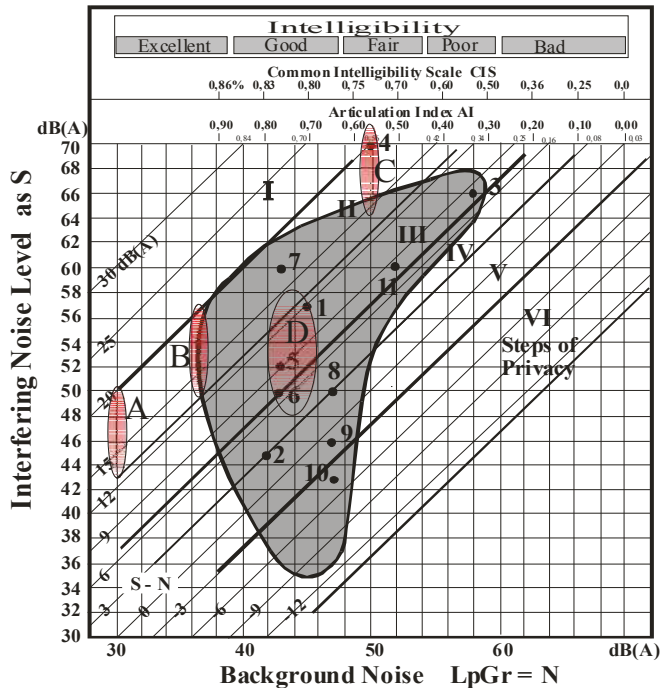


Fig. 5 Field of confidence in Open-Plan Offices OPO

1 VDV 2569 speech loud/ 2 as 1 quiet/ 3 Call Center loud, hectic day/ 4 office 6 places/ 5 OPO with barriers/ 6 OPO with barriers/ 7 OPO team/ 8,9 OPO with barriers/ 10 very damped/ 11 as 3 quiet, normal day, A Campus/ B DBAG Frankfurt/ C single offices/ D VDI 2569 recommendation

To the challenge of architectural design

The design must be related to the workplace and must include the influences of sound, light, and air /5/. It sounds better for instance if the light and the colours are pleasant. This does not imply to have a dark environment with a little spotlight on the desk. Instead a bright light is desired of around 500 lx without blinding through, e.g. lights underneath the ceiling. The walls should be covered with sound absorbing material such as fabric on top of 5cm mineral wool. The same applies for the ceiling, the carpet on the floor or for free standing barriers around the working place.

In today’s office buildings Modern Design is a necessity. It follows the rules of, e.g. Feng Shui, differentiating between “yin” with the minor, dark, more quiet, introverted and relaxing; and on the contrary “yang” with major, bright, movable, more extrovert /12/13/14. OPOs have an extended need

for balance between clear structures and creativity as well as concentration and vital workflow. From the authors' experience in business-design the choice of color scales, intelligent furniture patterns, light settings, plant concepts and acoustical comfort reflect a system, that the authors call "The principles of Harmony". They stimulate all 5 human senses through the elements of fire, metal, earth, wood, and water. Water for example is connected to the ear. So it becomes obvious that OPOs have numerous "Fields of Confidence", which wait to be discovered and explored.



Fig.6 Design elements and presentation

Fig. 6 indicates the attempt to find optimal solutions by presenting materials for wall coverage, as carpets or window stores.

Summery, outlook

Acoustical design today is part of interior design. The goal here is to consciously blend both for the purpose of integration of the human sensory system as the most important standard. The authors are looking forward to the challenge of creating OPOs that "feel" like landscapes and look like modern life design.



Fig. 7 Open space with only a few free-standing barriers and with BGN = 47dB(A)



Fig. 8 Colors, free standing barriers, wood in OPO design, background noise 47 dB(A)

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