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ENHANCING ACOUSTIC DESIGN IN OPEN-PLAN OFFICES. PRACTICAL APPLICATIONS OF THE SIMPLIFIED ISO 3382-3 PREDICTION MODEL

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ABSTRACT

ISO 3382-3 is used to assess sound propagation and speech intelligibility in open-plan offices, based on speech sound pressure levels and transmission indices measured at workstations [1]. Although there is no defined calculation method, room acoustic computer simulations can be used as an alternative. However, modelling and verification are often complex and costly. Hongisto and Keränen present a simplified prediction model for the ISO 3382-3 parameters, tested with measured data from 10 open-plan offices [3].

In a specific project, this new calculation method was implemented during the office fit out phase to assess the acoustic quality related to different activities in different areas. The approach considered the impact of objects, such as acoustic screens in between workstations, for optimal user centric design. The method's flexibility and immediate results allowed for agile application, which was later validated by on-site measurements of the final design. These findings are presented in this publication, emphasizing the effectiveness of the model in real-world scenarios. Recommendations for its use and a discussion of the limitations of the method are also provided.

Keywords: *iso 3382-3, acoustic quality, open-plan offices, prediction model, user-centric design.*

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1. INTRODUCTION

ISO 3382-3 provides room acoustic parameters to assess sound propagation and speech intelligibility in open-plan offices, and these parameters have been widely adopted in the design process since their standardization in 2012. To determine these parameters, speech sound pressure levels and speech transmission indices (STI) are measured at workstations along a designated measurement path, using a sound source (imaginary speaker) positioned at the start.

While ISO 3382-3 serves as a measurement standard, it does not define a calculation method for its parameters. Nevertheless, the required input data, including speech sound pressure levels and STI values, can be calculated through room acoustic computer simulations. Although advances in computing power have alleviated some limitations, the modeling and verification of computer-generated models remain complex, time-consuming, and costly.

Keränen and Hongisto [2] present a method for predicting ISO 3382-3 values using regression models based on measurements from 16 Scandinavian open-plan offices. This approach provides a means to obtain initial estimates of ISO 3382-3 values during the planning phase, allowing for rapid and cost-effective comparisons of different room configurations, ceiling layouts, and furnishing options.

Building on this predictive model, the current study explores its application in a practical context, assessing its effectiveness during the office fit-out phase for determining acoustic quality across various activities and areas. By considering the influence of design elements such as acoustic screens between workstations, the method emphasizes a user-centric approach. The subsequent analysis validates the model through on-site measurements, illustrating its real-world applicability and providing insights into its limitations.

2. METHODOLOGY

The method is only briefly presented here. For further details refer to Keränen and Hongisto [2].
The spatial decay rate of the A-weighted sound pressure level (SPL) of speech is calculated using

$$D_{2,S} = 8\frac{h}{H} + 0.16\frac{L}{H} + 4\alpha_c + 1.7\alpha_v \tag{1}$$

The A-weighted SPL of speech at 4 m from the speaker is calculated by

$$L_{p,A,S,4m} = L_{p,A,S,1m} - 3h - 0.1W - 4.6\alpha_c - 0.8\alpha_v \tag{2}$$

The variables are defined as follows:

L	Room length
W	Room width
H	Room height
h	Screen height
α_c	Ceiling absorption
α_v	Vertical absorption
$L_{p,\mathrm{A,S,1m}}$	A-weighted SPL of speech in 1m distance, in dB(A)

The screen height h is the average height of partitions and interior (cabinets, etc.) along the intended measurement path. For the ceiling absorption α_c, the average sound absorption coefficient of the ceiling (250Hz - 4000Hz) can be used, multiplied by the coverage (factor 0.0-1.0).
The vertical absorption α_v, summarizes the average absorption on the walls, floor, partitions, and other interior objects in a single value. Typical values for α_v range from 0.1 for all vertical surfaces have no sound absorption to 0.6 for large rooms with distant walls, wall absorbers, and sound-absorbing screens.

3. APPLICATION

A new workplace concept was developed in collaboration with a management consultancy as part of a major campus project for a food company with around 2.000 employees. The rough description of this concept is based on the principle of an activity-based setting and thus a possible mix of activities in shared open-plan office spaces. During the concept phase for the development of the new working environments, particular attention was therefore paid to spatial acoustic planning. The room type 6 approach in accordance with ISO 22955 supported the planning and the target parameters served as the basis for planning essential room acoustics measures such as ceiling design and screen measures.

3.1 Activities

In most areas of the new offices, different departments will share space and also use common so-called *overflow zones*. Therefore, the potential conflict of disruption to employees took centre stage and was intensively investigated. However, no more than two different departmental activities and the activity in the overflow zone, which cannot be precisely defined but is generally communicative, were identified.
According to Table 6 of ISO 22955 shown in Figure 1, the following contrasts result, for example: informal meetings in the overflow zone vs. collaborative working with a target $D_{A,S}$ value (in situ acoustic attenuation of speech) of 15dB or non-collaborative working with 21dB or the situation of collaborative working and focussed individual work with a $D_{A,S}$ of 26dB.

Source/receiver space type	Informal meetings (open plan)	Outside of the room communica-tion (phone)	Collabora-tive	Non-collabora-tive	Focused phone	Focused individual work
Social and welfare	15	15	18	24	27	32
Informal meetings (open plan)	15	12	15	21	24	29
Outside of the room communication (phone)			12	18	21	29
Collaborative				18	21	26
Non-collaborative					18	23
Focused phone					21	26

NOTE 1 In order to keep the noise level within the social and welfare space under control and avoid Lombard effect, a certain amount of absorption is needed. It is recommended to have an absorption area of at least 90 % of the floor surface. $A/S_{\mathrm{Floor}} = 0{,}9$.

NOTE 2 These values are derived based on assumptions regarding background sound levels, source vocal effort, and proposed signal to noise ratios. These values may vary depending on the context.

Figure 1. Potential $D_{A,S}$ ratings between different types of spaces.

3.2 Examples from the concept phase

The floor plan shown in Figure 2 shows colored markings at the edge of the activities planned for the areas.

Figure 2. Exemplary office area and indication of the planned activities (colored marking at the edge: turquoise: rather quiet; blue: communicative and lively way of working; orange: conversation should rather not be understood)

The possible room acoustic measures for influencing the necessary target values are shown in Fig. 3.

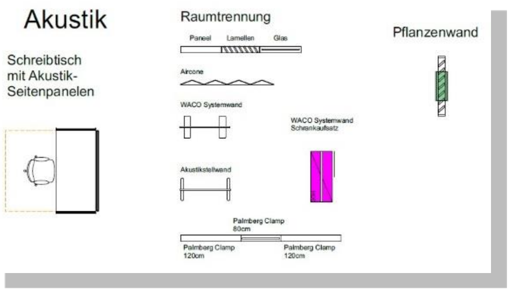

Figure 3. Insight into the movable room acoustic equipment: e.g. shielding at the workstation and acoustic partition wall

The room acoustics measures, which can be found throughout the building, can be described as carpeting, free-hanging panels and wall absorbers. Thanks to this high-quality equipment, shielding measures at desks, between desks or between zones by the different solution shown in Figure 3 can have an effect of varying quality.

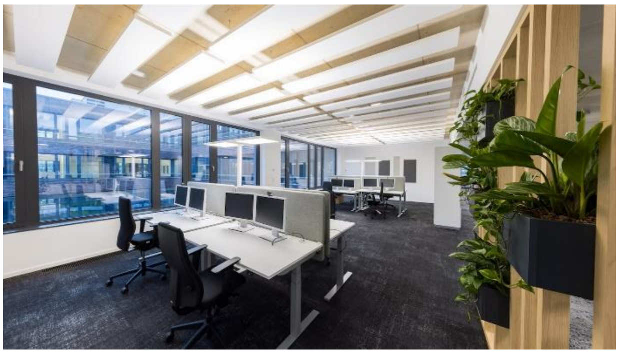

Figure 4. Typical office area with building equipment such as carpeting, free-hanging panels and wall absorbers.

As the employees in the old office space had a completely different type of organizational structure, intensive work was carried out to prepare for the new open space situation. The principle of ISO 22955 room type 6 was applied when advising the team responsible for change management. As the target fulfilment of the $D_{A,S}$ parameter had to be achieved dynamically at different locations and by varying the room acoustic measures of the furnishings, the simplified model of predicting the ISO 3382-3 parameters was used. The $D_{A,S}$ value could be calculated using the result of the ISO 3382-3 parameters. The $D_{2,S}$ could be used as the gradient of a regression line and $L_{p,A,S,4m}$ as an anchor point and assuming the endless continuation of the office space and the corresponding reduction of the sound pressure level along a measurement path. The exact description of this procedure is not the subject of this paper, but was discussed and tested in detail in [4]. Using this method, a required distance in meters can be determined based on the forecast and the target value of the $D_{A,S}$. The principle made it possible, within the limits of the method, to calculate as many variants as possible, taking into account the different activities in the contrast. This helped enormously in deciding the minimum requirements of the equipment as well as a responsible use of the budget. In comparable cases, too much sound absorption is often used in different places due to the high fear of the lack of acceptance of the open space by the employees.

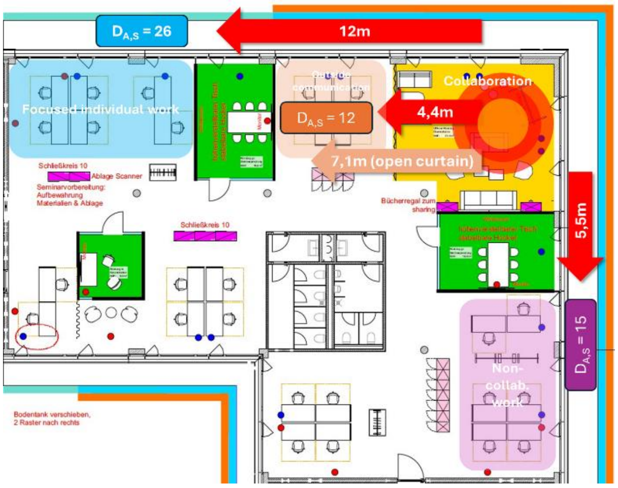

Figure 5. Insight into the planning of the spread of activities in the open office based on the potentially largest emission in the overflow zone and the empirically determined necessary distances

3.3 TOP Modell

When considering occupational health and safety aspects, technical, organizational and personal intervention levels are often described. The organizational and personal contributions to noise reduction are indispensable but are not dealt with in the classic standards and guidelines on room acoustics. Work situations cannot be regulated by a single acoustic limit value.

For this reason, acoustic working conditions should be regulated according to the T-O-P (technology-organization-personnel) principle, which is also recognized in the field of prevention. Technical acoustics are understood here as all possibilities that contribute to an ergonomically favorable room design. This includes absorbers (at the ceiling, on the walls, etc.), partition walls (upright, suspended, etc.), furniture, curtains and other suitable measures. In addition to the technical design of a room, the organization of office buildings can contribute to an ergonomically favorable acoustic room design. Workplaces should be organized according to acoustic criteria. The procedure described supports this and combines the technical and organizational levels.

3.4 Validation by measurements after construction

Once the structural measures had been implemented and the employees of the various departments had moved in, measurements of the room acoustics were carried out. This involved measuring the classic room acoustics parameters in accordance with national specifications. It was also decided to analyse the $D_{A,S}$ parameter of one department in detail. Due to various circumstances, it was not possible to determine the exact department and measurement positions that were originally considered in the concept phase. Assuming the known limitations of the method used, this was not decisive but served the overall concept of change management and the decisions for structural and equipment quality measures.

Figure 6. Overview of the measurement results of the $D_{A,S}$ after implementation of the spatial-acute concept

At this point, therefore, only exemplary conclusions can be drawn regarding applicability. In any case, it should be noted in advance that, according to feedback from the planning team, employee satisfaction is very high in view of the contrast to the old working environment and the reports of noise problems and disruptions in the open spaces are at a low level. In this context, it is relevant to mention the Leesman Index benchmark and the conclusions drawn by Radun and Hongisto [5], which show that over 35% of employees in open-plan (flex) offices report dissatisfaction or complaints due to noise. These findings are based on responses from 82,315 participants across five countries.

Based on sound emissions in the described overflow zone (yellow) in Figure 6, for example due to collaborative work, the measured $D_{A,S}$ is shown at positions 18 with a value of >28dB. This fulfils the wish of the organizational planning to have a quiet working environment in this area, which corresponds to the activity of focused individual work, for example, with a target value of $D_{A,S}$ of 26dB corresponding to Table 6 shown in Figure 1. Another example would be the effect of a protected area in the immediate vicinity for non-collbarorative work with a $D_{A,S}$ of 12dB due to a curtain. This is also shown to be fulfilled at position 10.

4. CONCLUSION AND DISCUSSION

The prediction of the analyzed parameters of speech sound propagation can be carried out with few input parameters and little time expenditure. The results of the calculated speech level at a distance of 4 meters and the spatial decay rate of speech are within the range of the compared measurement results - taking into account the described inaccuracy of the model.

The input of meaningful data, especially ‘ceiling absorption’ and ‘vertical absorption’, is an important prerequisite for minimising the inaccuracy of the results. This requires appropriate prior experience in the assessment and documentation of the absorption of room, furnishing and furniture surfaces.

The prediction accuracy is not always good, but tends to be sufficient for the practical approach and purpose of the model according to its authors [3]: Such an approach is advantageous in situations where the effect of different room variables on room acoustics is to be demonstrated to e.g. planners. This can be achieved in a short time due to the simplicity of the model.

In addition to the prevention of the relationship through technical and organizational measures, behavioral prevention is of great importance. It is extremely important to implement the technical level of room acoustics in an ideal way. However, it is not helpful to consider the findings in room acoustics independently of room utilization and the associated activities. For this purpose, a procedure has been developed on the basis of recognized standards to implement this practically in the planning and process of building projects. Another important aspect is that every employee can also contribute to a pleasant acoustic environment. To this end, personal work equipment is provided in accordance with the latest ergonomic standards. In addition, workshops help employees to understand and make ideal use of the technical and organizational offerings and to better assess any remaining disturbances and resolve them in a team, for example. This distributes the entire task fairly between the Construction and Facility Management and Human Resources departments.

5. REFERENCES

[1] ISO 3382-3:2022-01, Acoustics – Measurement of room acoustic parameters – Part 3: Open plan offices (2022)

[2] Virjonen, P. Keränen, J., Hongisto, V.: Determination of Acoustical Conditions in Open-Plan Offices: Proposal for New Measurement Method and Target Values, Acta Acustica united with Acustica 95(2) (2009), 279-290

[3] Keränen, J., Hongisto. V.: Prediction of the spatial decay of speech in open-plan offices, Applied Acoustics 74(12) (2013), 1315–1325

[4] Wassermann, E.: Practical Application of ISO 22955 for Acoustic Design in Open-Plan Offices, DAS/DAGA Copenhagen (2025)

[5] Radun, J., Hongisto, V.: Perceived fit of different office activities – The contribution of office type and indoor environment, Journal of Environmental Psychology (2023)