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# CONTRASTING OPEN PLAN OFFICE DESIGN IMPLICATIONS FROM EMERGING FRENCH, GERMAN AND FINNISH STANDARDS

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This paper uses a new generic open plan office as a case study to investigate the design implications of the different national approaches to acoustic conditions in open plan offices. The implications of the Finnish, French and German standards for open plan office acoustics are compared. Design options are compared with geometric acoustic modelling of a typical open plan work area in an office with a continuous suspended ceiling. The most significant variation modelled is the height of screens between desks, with some variation to additional absorption. The height of screens required between desks to comply with a particular category or achieve a high classification in any of the standards may not be anticipated by the client who nonetheless wants "excellent acoustics". The screen height is shown to be more onerous for higher classification in the Finnish guidelines than the German or French standards. The risk of adopting an inappropriate rating system is that either the acoustic designer may find themselves to be in conflict with the architectural intent, or the occupant may be dissatisfied with the acoustic environment achieved. In the UK, either the French or German guidelines may be appropriate to use, depending on the type of project; the Finnish standards are less likely to be suitable.

Keywords: acoustics of open plan offices, acoustic classification system

## 1. Introduction

There has been a move from cellular to open plan office environments in many countries over recent years, for many reasons including reduced cost associated with space requirements as well as opportunities for more collaborative working. Acoustic conditions in open plan offices have come under close scrutiny, as they are frequently cited as a reason by occupants to resist the new workplace environment. According to Oseland [1], noise is one of the top causes of dissatisfaction and loss of productivity in the workplace, and the psychological impact of noise is the main cause of concern in office environments. Oseland refers to the Leesman Index which indicates that noise is the second biggest cause of dissatisfaction (according to 47 % of respondents), after temperature control.

ISO 3382-3 [2], published in 2012, defines acoustic parameters that can be measured in open plan offices and used to assess the acoustic quality of the space. Although the draft version of the standard contained an example of target values that could be used for evaluation in an informative annex, this was omitted from the final published version. Subsequently some European countries have developed guideline values for open plan offices based on the acoustic parameters in ISO 3382-3; however, different countries have taken different approaches and use different parameters. The UK has not addressed this task, which leaves no national guidance based on the parameters of ISO 3382-3. As such, the acoustician in the UK has the choice of which guideline values to adopt when evaluating the acoustic quality of open plan offices.

While different countries' guideline performance values vary, it is not clear why this should be so. It is implicit that people in different countries have different expectations for acoustic performance in open plan offices. In fact there are significantly different expectations for the interior architecture in open plan offices in different parts of the world. To adopt the performance standards from a foreign culture that has different expectations of how an open plan office appears and sounds can lead to disappointment. The purpose of this paper is to help avoid that pitfall by highlighting the contrasting performance and design implications of the Finnish, German and French standards.

## 2. Country guidelines

A Finnish standard [3] from 2004 includes guidelines for open plan offices. A further guideline in 2008 for offices [4] takes into account what became the ISO standard 3382-3 in 2012. The guidelines identify acoustic categories for open plan offices from A to D. The subjective classification ranges from 'Excellent' to 'Poor'.

The German VDI recently released a revised version of their standard dedicated to offices, including single person offices and open plan offices [5]. This standard identifies three Classes A, B and C which define different levels of input and intent for the acoustic conditions. While the Class C is understood to provide a minimum comfort, the Class A is described as being the best achievable for an open plan office.

Following a previous standard for open plan work places in 2006 [6], the French standards institute released a fully dedicated standard to open plan offices in 2016 [7]. This standard dropped the classification system to provide requirements for different intended use of the office. A good acoustic comfort is therefore described for four types of use, from phone conversation (call centre) to light and extensive collaborative work. The summary of the various intent is shown in Table 1.

| **French – NF S 31-199: 2016** | | **German – VDI 2569: 2016** | | **Finnish RIL 243-3:2008** | |
|---|---|---|---|---|---|
| **Type 1** | Telephone work | **Class A** | High input | **Class A** | Excellent |
| **Type 2** | Collaborative work | **Class B** | Middle input | **Class B** | Good |
| **Type 3** | Low level collaborative work | **Class C** | Low input | **Class C** | Fair |
| **Type 4** | Public reception | - | | **Class D** | Poor |

**Table 1: Subjective classification of country standards**

The different classification systems each select their own parameters as well as performance values. Although ISO 3382-3 is the obvious starting point to identify relevant parameters, the pertinence of some of the parameters is questioned by some practitioners [8], [9]. The reverberation time and the STI (Speech transmission Index [10]) are the most contentious parameters. While the German standard determined to disregard the STI, it maintains the reverberation time as part of the requirements. However, this is to be considered only for source – receiver distances between 2 and 8 metres, the range over which it is relevant, as it is known that the $T_{20}$ is dependant of the distance. Omission of the STI means that masking sound cannot be used to help control acoustic conditions: the classification is therefore controlled by the internal building fabric and with ventilation noise limits. The German standard adds detail on measurements as well as design. Requirements distinguish various section of measurement lines where acoustic criteria apply differently.

The Finnish approach is to disregard the reverberation time as unreliable but maintain the radius of distraction (the $r_D$ is where STI < 0.5) as part of the requirements. The radius of distraction can be controlled with masking sound. As the French standard considers various type of uses, it introduces additional parameters, most significantly the level of attenuation between workstations. As the different *Types* in the French standard refer to different intended use of the space, one *Type* is not necessarily classified as better than another *Type* for the intended use – they should not be compared hierarchically. For consideration in this paper the requirements have been simplified for clarity, and the Type 4 in the French standard is disregarded as a special case. The summary of the different parameters is shown in Table 2.

| Parameter | FRENCH – NFS 31 199: 2016 | | | GERMAN – VDI 2569: 2016 | | | FINNISH – RIL 243-3:2008 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Type 1 | Type 2 | Type 3 | Class A | Class B | Class C | Class A | Class B | Class C | Class D |
| $D_{2,S}$ | > 7 | > 9 | > 7 | ≥ 8 | ≥ 6 | 4-6 | > 11 | 9-11 | 7-9 | < 7 |
| $D_n$ | ≥ 6 | ≥ 4 | ≥ 6 | - | - | - | - | - | - | - |
| RT | < 0.6 | < 0.6 | < 0.6 | ≤ 0.6 | ≤ 0.7 | ≤ 0.9 | - | - | - | - |
| $RT_{125\ Hz}$ | < 0.8 | < 0.8 | < 0.8 | ≤ 0.8 | ≤ 0.9 | ≤ 1.1 | - | - | - | - |
| $L_{Aeq}$ | 48-52 | 45-50 | 40-45 | - | - | - | - | - | - | - |
| $L_{bkg}$ | - | - | - | ≤ 35 | ≤ 40 | ≤ 40 | - | - | - | - |
| $L_{p,A,S,4m}$ | - | - | - | ≤ 47 | ≤ 49 | ≤ 51 | < 48 | 48-51 | 51-54 | > 54 |
| $r_d$ | - | - | - | - | - | - | < 5 | 5-8 | 8-11 | > 11 |

**Table 2: Comparison of acoustic parameters between different standards**

Consideration of the acoustic parameters and their variation across the selected guidance can illustrate a better idea of the acoustic implications of the design for the occupiers of the space. The Finnish guidelines require a significantly higher spatial decay of sound, $D_{2,S}$ than the other standards. Class B in the German standard may achieve only the lowest Finnish category, whereas the highest German Class may only achieve Class C in the Finnish guideline. This could suggest that the Finnish guidelines give more weight to acoustic separation between work stations than to collaborative work. A lively and collaborative work environment with easy transmission between workstations scores poorly in the Finnish guidelines. However, due to a lower decay over distance, the highest German Class requires a lower speech level at 4 metres, $L_{p,A,S,4m}$ than the highest Finnish Class in order to control the excess of noise disruption possible on nearby work stations.

The French standard offers more context behind the requirements by moving away from a classification system. The purpose and reasoning in achieving particular values for different parameters in the design is explained in terms of the proposed use of the open plan work space – whether for more collaborative or individual work, or for a call centre. The values are indicated as the minimum for a good performance for each particular open plan work environment type.

With a fixed desk layout in a proposed office development, the following analysis tries to illustrate various design features and their implications for classification under the different standards. This is not a true comparison between the various guidelines; for example, for a particular type of use the French standard would encourage the design to reflect that purpose, rather than be of a generic type. However, it is useful to demonstrate to the reader the implications of design features on the different classifications.

## 3. Modelling and calculations

The modelling is undertaken with CATT Acoustic [10], a geometrical acoustic modelling software. A typical office is modelled and the implication in terms of acoustic design considered in this paper are limited to the three typical components: absorption, screen height and masking sound. This choice is made in order to simplify the comparison but also to highlight the importance of the office layout and use. The algorithm 1 (first level of accuracy) is used with CATT acoustics including diffraction. The modelled office layout is typical for a new design in the UK. The space modelled has 150 workstations in an overall area of 693 $m^2$, giving a density of 4.6 m / workstation, as illustrated in Figure 1.

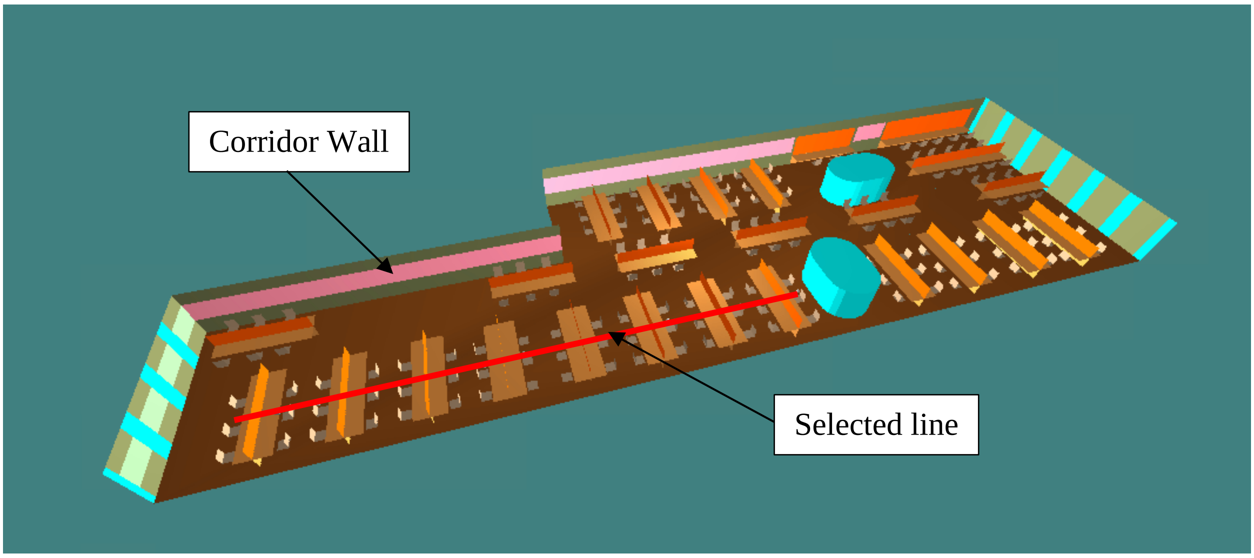


**Figure 1: Model of the open plan office**

Various levels of acoustic treatment are used to reflect the requirements set by the standards and guidelines within a generic space that has a suspended ceiling. In spaces with rafts or baffles rather than suspended ceilings, as is becoming increasingly common in practice, the requirements for screen heights and other absorption would vary from those here. Various lines have been calculated but only one is reported here for simplicity. The level of acoustic treatment includes wall panels, height of screens (see Figure 2), use of absorbent screens and use of a masking sound system. The most significant difference is the height of the screens; the options are summarised in Table 3 with the use of sound absorption Classes as described in ISO 11654 [12].

| Element | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| **Ceiling** | Class A | | | |
| **Floor** | Carpet | | | |
| **Wall panels** | No | | Corridor wall | |
| **Screen height / m** | 1.1 | 1.3 | 1.5 | 1.8 |
| **Side Screen** | No | | | Yes |
| **Absorbent screens** | No | | Class B | Class A |
| **Masking sound, dB(A)** | 35 | | | |

**Table 3: Summary of acoustic treatment options**

Each option is modelled and the various parameters are calculated. A set of parameters is shown for each option and then compared against the guidance. The reverberation time is shown for each option. It is calculated following the guidance of the German standard which requires the reverberation time to be measured between 2 and 8 meters from the source. The results are shown in Table 4.

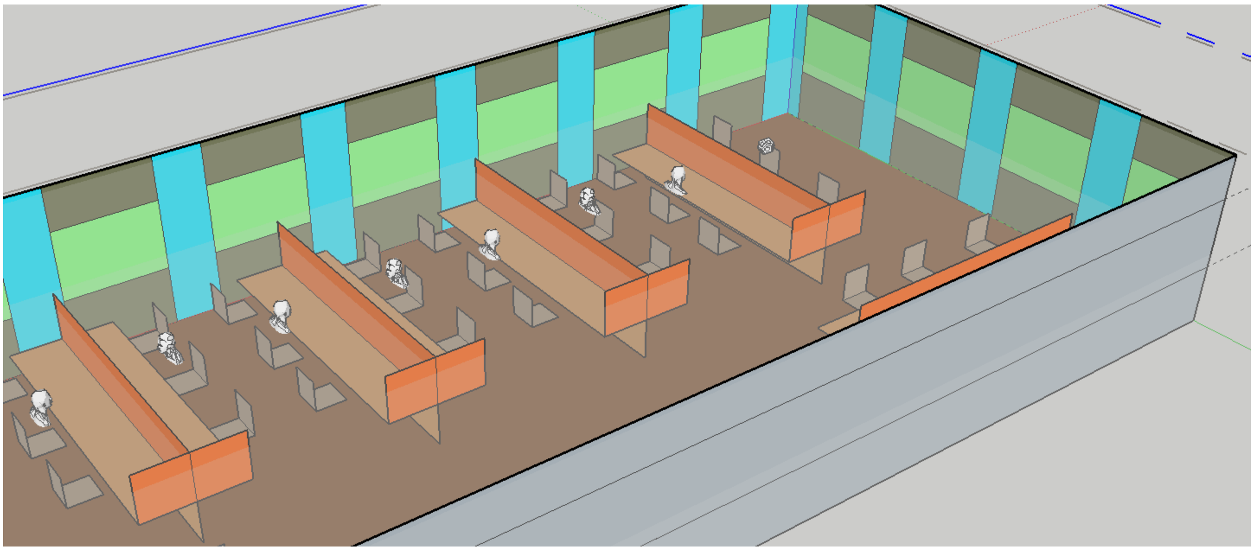

**Figure 2: Zoom on side screens between desk and circulation, Option 4**

The single parameters $L_{p,A,S,4m}$, $D_{2,S}$, and $r_d$ are shown in Table 4. The single-figure $D_{2,S}$ is very sensitive to the presence of screens and the position of the receivers. When the line-of-sight is not achieved (i.e. obscured by screens), whether the first and last position are located before or after a screen may significantly influence the derived $D_{2,S}$ and therefore impact the results. As such, the selection of the line has a significant impact on the results or the design and a range of lines should be used in practice. The range of study described in ISO 3382-3 is from 2 to 16 m. An alternative graphic calculation with CATT is further discussed in the next chapter.

| Parameter | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| $L_{p,A,S,4m}$ / dB | 48 | 46 | 43 | 42 |
| $D_{2,S}$ / dB | 4.4 | 5.7 | 7.1 | 9.2 |
| $T_{125Hz}$ / s | 1 | 0.9 | 0.8 | 0.7 |
| $T_{0.5\text{-}2k}$ / s | 0.7 | 0.6 | 0.4 | 0.3 |
| $r_d$ / m | 8 | 6 | 5-6 | 5 |

**Table 4: Calculated set of single-figure parameters for each option**

Option 1 is considered as a typical design for an open plan office in the UK that would comply with the scant UK guidance, as it has a Class A absorbent ceiling. The calculation shows that this fails to achieve a level of "good" acoustic in any of the other country standards considered. This may reflect the feeling of "disruptive noise" common in open plan office environments. Option 2 is calculated to nearly achieve Class B in the German standards. In this case, the addition of wall panels would help increase the $D_{2,S}$. However, in the layout studied, this may reduce the reverberation time further which may not be desirable, as this reduces the background sound from more distant sources within the office which contributes to the masking sound as opposed to distraction.

With this layout, in order to achieve the strong decay required to achieve the "good" criteria in both the French standard and the Finnish guidelines, higher screens as well as absorption are required. This leads to a very low calculated reverberation time in Option 4. To maintain a high $D_{2,S}$ without damping the space too much, higher screens or a cubicle design would need to be implemented. A summary of the various classification achieved by each option is shown in Table 5. To achieve the full Class/ Type, all parameters need to meet the performance requirements.

| **Standard / Screen height** | **Option 1** | **Option 2** | **Option 3** | **Option 4** |
|---|---|---|---|---|
| | **1.1 m** | **1.3 m** | **1.5 m** | **1.8 m + side** |
| **Finnish Class** | D, "Poor" | D, "Poor" | C, "Fair" | B, "Good" |
| **German Class** | C | C-B | B | A |
| **French Type** | None | None | 1 & 3 | 1, 2 & 3 |

**Table 5: Classification of designs under different country guidelines**

This shows than with the proposed layouts, some of the parameters are lower than required in the guidance which could indicate that the layouts are not well optimised, as discussed below.

## 4. Discussion

The calculations show that different acoustic treatment is required to achieve an equivalent classification of "good" performance under each standard. There is no single answer to the question of what acoustic treatment is needed to achieve a particular semantic performance across the different country standards. An architectural design can therefore be classified as 'Fair' or 'Poor' if inappropriate guidance is chosen to assess the proposed office. This is a critical aspect as the cultural expectation for the interior design of an open plan office is not discussed in the different country guidelines.

As highlighted by the calculations, the acoustic treatments are limited to provide the best acoustic to achieve the desired requirements. The layout is of vital importance in the design process; knowledge of the end-use should inform the design. The German standard also includes information on planning and layout in a psychoacoustic type approach for multi-person offices, to provide appropriate zoning for occupancy and function. Thus the intended use of the space is accommodated in a different manner from the French standard.

In the French standard, the level of collaborative work drives the criteria to reflect the level of protection required. A Type 2 use for 'Collaborative work' requires a higher spatial decay of sound, $D_{2,S}$ and a lower level of attenuation between workstations, $D_n$. To ensure the expectation of the users are met, 'bays' of collaborative work can be implemented with low screens while the separation to the next bay can be more significant to ensure the spatial decay of sound requirement $D_{2,S}$ is satisfied.

A fixed layout may require a level of acoustic treatment that while benefitting a criterion may decrease another one. Acoustic input in the office layout is therefore important. Due to the fairly dense layout in the example presented, achieving a high $D_{2,S}$ with the use of desk dividers significantly reduces the speech level at 4 m, $L_{p,A,S,4m}$. This may not be desirable if large collaborative groups are required. The layout would need to be adapted or the guidance used revised.

Other parameters can be easier to control; for example the radius of distraction, $r_d$ can be controlled with a masking sound system to allow more flexibility in the interior design of the fabric according to the Finnish guidelines. The level of masking sound is in this study is low such that the background sound level in practice is likely to achieve this level. This shows the classification of the design in the absence of a dedicated masking system, although higher masking sound is likely to be desirable in practice. Masking sound systems are gaining popularity and credence in the UK, albeit many designers and clients still regard them with suspicion. As they are also a significant cost, it can be difficult to argue for their use.

The $D_{2,S}$ is the only criteria considered throughout the selected guidance in this paper. However, calculation of this parameter is very sensitive to the presence of screens between source and receiver positions. In its Catt-Acoustic notes [12], Dalenbäck discusses the pertinence of this parameter. Originally described as a ‘line-of-sight’ decay over distance in ISO 14257 [12], it is used in ISO 3382-3 as the line passing via workstation including screening from desk dividers and cupboards. As such, the decay is significantly affected by the screening and the single-figure value calculated may vary depending on the line and receptors chosen. An alternative method can be used to to determine the single-figure value; a graphical representation generated with Catt-Acoustic is referred as a “creative use” of the $D_{2,S}$. By visually observing lines, an average single-figure $D_{2,S}$ can be derived rather than a single number.

This paper only considers modelling without in-situ measurements; the purpose of this is to offer a comparison of the various standards and requirements by maintaining a consistent assessment methodology. For comparison, the German standard provides useful typical acoustic treatments to achieve the various classes and these are in line with the options considered in this paper. The lack of measurements in existing offices is an acknowledged limitation and would need to be considered in further work.

## 5. Conclusion

In countries where standards or guidelines for open plan office acoustic conditions are yet to be published, there may be little guidance on how to choose a suitable standard or classification system for a particular project. Where the cultural expectations of an open-plan office in another country are not well understood, the choice of which standard to follow can have significant implications. This paper illustrates the direct acoustic and interior design implications that vary significantly between different country guidelines.

The German standard includes detailed guidance on examples of design features to achieve each Class of performance, and suggests which types of use may be suited to particular Classes. The intended use for occupants is explicit in the French standard which aligns the acoustic performance requirements with the type of use. The height of screens between desks required to achieve a high classification may not be acceptable to the client; in this instance, it is considered the Finnish guidelines are less likely to be suitable in the UK. For the guidance using a classification system, it is important to frame its subjective meaning or a project has the risk of failing to meet expectations. At the design stage, it is critical to use a classification system or semantic guidance that is consistent with the expected use so that the architectural and acoustic intents are consistent. Further work would need to include measurements of various types of offices in the UK in order to establish guidelines more specific to the cultural expectations of UK office developers and users. Until that data is available, the use of either the French or German standards is likely to be useful.

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