Acoustic of open spaces - toward a new French standard

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Summary
Taking noise disturbance into account in office space construction and planning is now a major objective for the experts participating in international standardisation groups. In 2012, the international standard ISO 3382-3, specifying the method of measuring the acoustic properties of open-plan offices, came into effect. Today, the standard is used by the majority of European acoustics consultancy firms. Nonetheless, the progress made by this standard presents some limitations, according to the experts from commission S30D of the French Standardization Organization (AFNOR). Notably, the standard does not differentiate between the different types of existing open office; similar comments could be made in reference to the French standard NF 31-080 used by most of the French acoustics consultancy firms.
The objective of the new French standard, drafting of which has been in progress since 2007, is to define different types of open-plan office, then to outline, for each of them, the indicators for assessing the acoustic quality, to define target values and to give the measurement procedures in detail.

1. Introduction

Over the last ten years, the use of non-partitioned spaces for offices has increased considerably in France. This growth has been based on the generally accepted idea that doing away with partitions stimulates communications and information-sharing. In addition, such solutions offer considerable flexibility and facilitate reorganisation. Another advantage is that the investment costs are low because it is possible, while spending less, to accommodate more people than in a space containing more traditional partitioned offices.
The reality today is that many people who work in open-plan offices complain of discomfort and disturbance due to poor acoustics [1-5]. Beyond the concepts of discomfort, disturbance, disruption, and annoyance, recent scientific studies [6-9] show that the acoustic ambience of an open-plan office can have negative consequences on the performance and on the quality of the work done.
French Standard NF S 31-199, drafting of which is in progress, is based both on the scientific studies on discomfort and disturbance in open-plan offices and also on the work of international standards organisations and societies. However, it departs from those organisations in that it considers that not all types of open-plan office can be addressed in the same way because the issues are very different when working, for example, in a call centre, than when working in a space that receives the public or other visitors.
Four families of space have been defined: call centres, project spaces, administrative spaces, and public reception spaces. For each family, an analysis of the activity has been conducted that should ultimately make it possible to establish a list of relevant indicators and of associated target values.
In this article, firstly we present the main standardisation work on the subject at international level, as well as French Standard NF S-31-080 used up until now for all types of offices and associated areas (including open-plan office spaces). Secondly, we show the approach around which the discussions are taking place within the standardisation group. Finally, on the basis of practical cases, we show what role could be played by certain acoustic indicators that are being considered for assessing the quality of rooms.

2. International standardisation

International standardisation is active on the subject of open-plan office acoustics:

- Standard RIL 243-3-2008 [10] drafted by the Finnish Association of Civil Engineers (RIL) is based on the use of acoustic descriptors such as the rate of spatial decay of sound pressure levels per distance doubling DL_2 [11] and the radius of distraction r_D which represents the distance from a source of sound beyond which a listener is in a comfort zone ($STI_r < 0.5$, the STI_r or "Speech Transmission Index" being a Speech Transmission index [12]). The standard recommends minimum values for these two indexes. Computer simulation software enabling forecast values to be compared directly with recommended values is available on the website of the Finnish Institute of Occupational Health (FIOH) [13].
- The Standard Guide for Open Office Acoustics [14] published by the ASTM (American Society for Testing and Materials) indicates that "…, a degree of acoustical privacy can be achieved if component selection and interaction are understood". It also notes that obvious risks of noise intrusion should be avoided; it gives information about the directivity of a speaker. It also indicates that the distractions caused by raised voices or by loud office equipment cannot be kept under control by normal open office construction methods, and that use of partitioned spaces is then recommended. Noise from telephone sets is addressed. Use of acoustic absorbents on the ceiling, on screens and on portions of the walls is recommended. Finally, the advantage of an electronic masking system is highlighted [15].
- Standard ISO 3382-3 [16] specifies methods of measuring the acoustic properties of furnished open-plan office spaces. That standard describes the measurement methods, the necessary instruments, the method of evaluating the measurement data, and the presentation of the acoustic test report. It also specifies the relevant indictors, while emphasising the use of D_{2S} which represents the decay of the sound pressure level per distance doubling, for a normalised speech spectrum.

That standard offers the advantage of being focused exclusively on open offices. However, its main drawback is that it makes no distinction on the basis of activity of the office. And yet, clearly, the expectations of people working in an open-plan office are not the same if the work is of a collaborative nature or requires extreme concentration.

3. French Standard NF S 31-080 for offices and related areas [17]

Up until the establishment of the acoustic standard for offices, NF S 31-080 (2006), France had no specific normative text relating to the comfort and to the acoustic environment of workspaces. That standard now establishes a link between measurements of the acoustic quality of a room and the levels of acoustic performance to be attained by means of features of the construction of the building. The performance levels are expressed by standardised and traditional acoustic criteria that are applicable to the building. It was written in such a manner as to help with drafting of specifications, and with design, execution, and acceptance of work. It is applicable to new spaces, to refurbishments, and to changes of use.

For all types of office, the standard defines the sound environment class according to three levels of performance ("Basic", "Effective", "Highly effective").

Standard NF S 31-080 is applicable not only for individual offices, but also for collective offices, open-plan offices, platforms to be fitted out/laid out, meetings rooms, training rooms, relaxation areas, and restaurants and canteens. It thus encompasses room typologies that are very different from one another. The main criteria recommended by Standard NF S 31-080 are the reverberation time T_r of the room, and the linear decay DL_2. For several years numerous acoustic measurements used reverberation time as the main indicator of performance for buildings. Such measuring is easy to perform. However, the values obtained in the office are not always representative of the acoustic quality. An inventory of a few acoustic indicators that can be used in the context of acoustics of non-partitioned offices, and some examples of acoustic treatment for such spaces are given in [18].

In view of the number of different activities that can take place in an open-plan office, the AFNOR S30D Commission decided to work on a new approach in order to gain a better grasp of the problem, and so as to correlate better with subjective experience.

The new standard is an opportunity to take the discussion deeper by addressing everything that goes to make up an open-plan office, including the additional items such as furniture, blinds, screens, etc.

4. The new standard NF S 31-199 – Open offices: programming, design, and use [19]

The ambition of this standard is to lay down principles, descriptors, and measurement methods that correlate well with subjective perception of sound. This new standard should also constitute a basis for thought and dialogue between the various players involved in creating and laying out/fitting out open-plan offices in France. In particular, it should enable project managers to hone their specifications, while also assisting them in their choices of acoustic objectives and resources as regards architecture and fitting out. Open-plan offices now have to adapt to accommodate all types of activity, which often have very different characteristics. Depending on the type of activity, the acoustic issues can differ widely, with, for example, need for intelligibility at certain locations of the open-plan space or for certain activities, or, conversely, need for discretion at the workstation or between the teams.
Standard NF S 31-199 thus defines four types of open-plan office space that are intended to encompass the vast majority of existing activities: call centres, project spaces, administrative spaces, and public reception areas. For each type, the issues are different because the activities are different.

4.1. Call centers

Call centers are open workspaces in which various activities (sales activities, technical assistance, etc.) take place essentially over the telephone. This type of workspace is generally characterized by large size, numerous sound sources and high density of distribution of people often exceeding the INRS recommendations of one workplace per, at least, 10 m^2 [20-21].
People are generally grouped together into small groups of 4 to 10 people by means of "suitable" furniture (bench desks or cluster desks). These people, who are facing one another, communicate frequently between two telephone calls or during break periods. The presence of supervisors or even "hypervisors" making it possible to manage and to monitor information flows adds conversations to the already existing babble.
The acoustic environment of the room should be conducive to doing intellectual work that requires a certain amount of concentration. It should also be comfortable for people so that they are not too tired and fatigued at the end of the day and over the longer term. The fitting-out of the call centre should thus be appropriate for satisfying these specific constraints. To that end, particular care should be taken with the ceiling and the desk dividers screen that separate the face-to-face workstations. They should behave as acoustic barriers while, at the same time, not offering too much resistance to natural light (Figure 1). Desk dividers also offer the possibility of increasing the absorption surface area of the room.

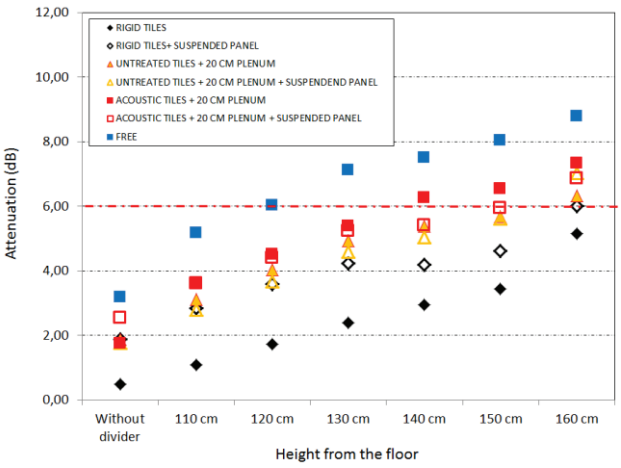

Figure 1. Attenuation of the speech spectrum (ISO3382-3) as a function of the height of the desk divider and for different types of ceiling (INRS measurements)

Other items of the room, such as the floor and the walls should be analysed, and parameters such as how the work is organised and how the people are distributed should be taken into account.
Indicators and target values will enable the expert acousticians who use this new standard to provide analyses and recommendations. Among such indicators and target levels, we might mention the level of background noise (equipment, footsteps, etc.), the ambient noise when people are present, and the spatial decay. The target values that are to be defined in the standard will be based both on simulations (see examples on Figure 2, [22]) and on in-situ measurements such as presented on Figure 3 [23].

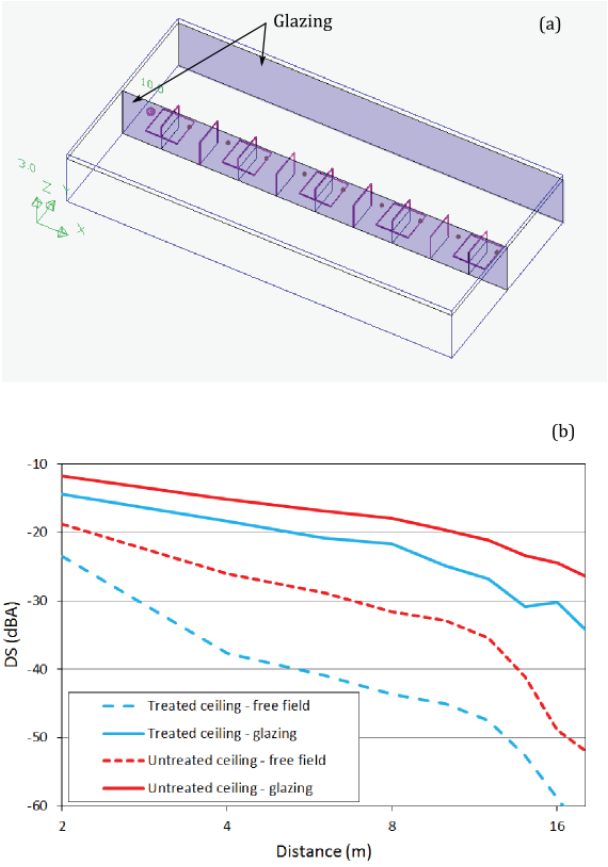

Figure 2. Simulation of decay curves in an open-plan office (performed with RAYPLUS software [22])

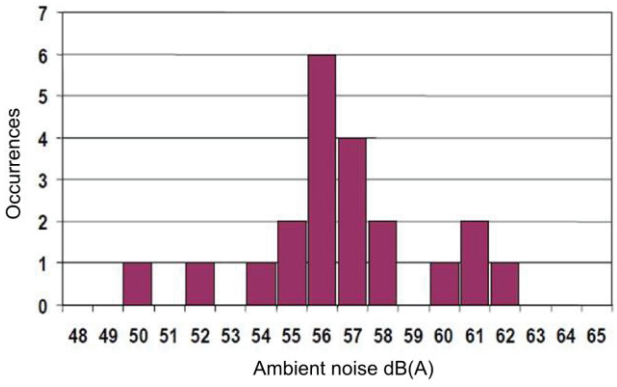

Figure 3. Distribution of the ambient noise levels measured in call centers [23].

4.2. Project spaces

This type of space is used for collaborative work. It is occupied by groups of people and teams working on the same project and who need to do individual tasks requiring limited concentration. This type of space is used, for example, by advertising agencies, marketing and sales agencies, consultancy firms, design offices, research centres, etc. Communications within the space are above all verbal. The number of simultaneous sound sources can be quite large and the sound ambience can be quite variable: a lively atmosphere with a lot of interactions. Good intelligibility is necessary between the people in the same team. Good intelligibility over the telephone is also necessary. However, there is also a need for discretion so as to keep things from people who, while working in the space, are not working on the project. An indicator that is, in principle, preferred for objectifying these concepts of intelligibility, discretion, or indeed confidentiality/privacy is the STI_r. On the basis of on-site measurements, it is possible to determine the intelligibility zones within an open-plan office, and thus to make layout decisions depending on the needs of the various departments or sections and on the expectations of the employees. As an example, Figure 4 shows a platform with a floor area of several hundred square meters. Measurements of STI_r were conducted in a portion of the room that included mini meeting rooms adjoining one another (points referenced 1 to 4 in Figure 4). In Figure 5, it can be observed that the intelligibility was always greater than or equal to 60%, that value clearly indicating lack of confidentiality for the conversations in one booth relative to a neighbouring booth, or even relative to a booth that was further away.

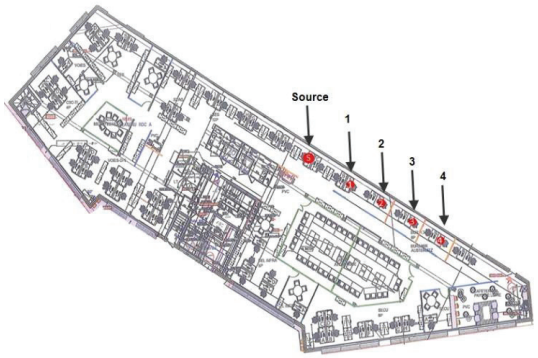

Figure 4. Example of a collaborative workspace: overall plan and measurement points for measuring STI_r in an open-plan office (the floor area of this platform is 850 m^2)

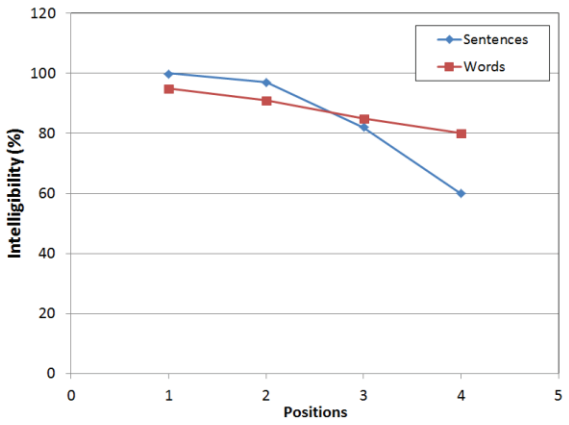

Figure 5: Intelligibility for the various measurement positions identified in Figure 4

The STI_r makes it possible to finely analyse the intelligibility in a room. However, deployment of measurement on a site can be complex, and acquiring the equipment can represent a cost that many design offices would not be able to bear. This an essential point to be taken into account by the standardisation commission when implementing the new standard.

4.3. Administrative spaces

This type of space is essentially intended for individual work. It is designed to host activities of the following types: business administration, accounting, human resources, purchasing, etc. The activity within a team in such a space is undifferentiated and non-collaborative. It requires high concentration from the employees, who are typically grouped together in teams of from 1 to 8 people, who can occasionally communicate (between colleagues, or over the telephone). The ambient noise level is therefore low over quite long periods (from several tens of seconds to several minutes), which sometimes gives rise to high emergences that can disturb the ambience of the open-plan office. There is therefore a need not only for intelligibility at the workstation, but also for discretion relative to the other workstations, in particular when several departments or sections are brought together within the same open-plan space.
This type of space was specifically investigated in the course of the Nice Report [24]. Those measurements were taken in five open-plan office spaces, and were accompanied by a survey gathering the subjective judgments of the staff. That investigation showed that the use of conventional room acoustics indicators is not sufficient to characterize an open-plan.
Implementing absorbent ceilings and screens made it possible to increase the spatial decay (4.8 dB(A) before and 8.4 dB(A) after) and to improve what the people felt, as shown in Table 1.

How would you rate the acoustic environment of the room?		
	Before	After
Number of answers (%)	15	10
Very good (%)	0	0
Good (%)	20	60
Neither good nor bad (%)	20	30
Poor (%)	40	10
Very poor (%)	20	0

Table 1: Results of the subjective questionnaire, expressed as percentages. The subject had to rate the sound environment before and after the works.

4.4. Public reception spaces

This type of space can correspond to reception areas of public bodies, insurance companies, banks, etc. It is organised to be conducive to holding meetings, and it should enable large numbers of interactions to take place between the staff and customers. The space is designed to receive the public and to facilitate individual work. The public can be received in spaces of the "counter" or "window" type or they can be seated in partitioned offices if the interview requires a longer time or a certain amount of privacy.
Between two interviews or appointments, the staff may have to input data or write reports, which requires relatively high concentration. In most cases, the activity of the employees is non-collaborative, and the exchanges take place face-to-face with the customer. The exchanges are often of a private nature, and it is therefore necessary to have a certain amount of discretion or indeed confidentiality. The sound sources, which consist essentially of verbal exchanges between people, are manifold and simultaneous. The voice levels in this type of space can vary to a large extent depending on the type of activity and on the period in question (e.g. during peak times).
The level of ambient noise is relatively high. Emergences are regular and sometimes very pronounced. The degree of disturbance due to such emergences is high.

5. Conclusions

After a few years of experience in using French Standard NF S31-080 that highlighted the diversity of situations encountered in spaces of the open office type, the standardization committee AFNOR S30D is proposing, in a new standard that is being prepared, a classification of open offices and a differentiated analysis approach. As a result, indicators and target values are being proposed that can differ depending on the zone in question: workstation, team, or department.

In order to cope with potential conflict situations, such as measuring noise at the workstations of office spaces, an appendix to the draft will also propose a measurement methodology, accompanied by parameters that describe the working situation and that should be recorded. Finally, in order to enable the disturbance/discomfort felt by people to be assessed, a questionnaire based on a recent survey [25] will also be proposed by way of information.

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