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### **Indoor Environmental Quality (IEQ). WHO CARES?**

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#### **KEYWORDS**

Indoor Environmental Quality, Thermal Comfort, Indoor Air Quality, Distributed Environmental Monitoring, System Integration, IE performance objectivation, new building procurement, IEQ expectations, management of expectations, IEQ-gap, occupants, IEQ Post Occupancy Evaluation, CfPB-indicator, IEQ complaint management, IE completion, IE specialist, Building owner's requirements, Performance specifications, Soft Landings.

#### **SUMMARY**

The need for objectivation of the indoor environmental quality (IEQ) increases since building project procurement practices, like Design and Build, etc, lay the entire burden of responsibilities for the specification and realisation of IE performances with competing market parties. But where does the client, let us assume the building owner, stand in this process? Is the building owner, in particular a non-professional one, when ordering the design and construction of a new building, sufficiently aware of what he buys regarding the IE and, more importantly, can he, after completion of the building, be absolutely sure that the IE turns out to be as expected?

Undeniably the (subjective) perception of the building's occupants should be given great prominence. However, the only objective way to reveal the IE-reality is to measure, preferably to monitor over a longer period of time. Either to obtain insights in reference to contractual obligations or to respond to occupants' complaints, thus putting knowledge on the side of the building owner, making his insights and judgment independent from the market parties. At the same time the question comes up what the position of the occupants is, who actually are the centre of all efforts. Is their wellbeing and productivity properly being taken care of?

This paper describes the market mechanisms that influence the IE performances and the need for professional specification and objectivation. It reveals a gap that exists between scientifically obtained perception data from large populations of building occupants regarding IEQ and that what in reality at building project level can be achieved, in particular in contractual terms. The non-technical powers, actors and factors, influencing the final IEQ achievement after building completion and the two stage character of the actual IE completion are also described.

In a co-paper<sup>[7]</sup> light is shed on the development of an objectifying measurement/monitoring tool for workplaces.

## 1 INTRODUCTION

The recent renovation of a substantial part of the 7.600 m<sup>2</sup> town hall of Dutch Municipality Horst aan de Maas, 42,000 inhabitants, has found its basis in completely outdated building services, in particular in outdated HVAC systems and poor IE performances. Further the 10 year old, better performing HVAC systems in a new build extension from 2004 were to be subjected to a thorough check-up, reset and recommissioning.



In the run-up to the project's definition phase, thoughts were given by the building owner and his IEQ consultant to the way this building-in-use project could be handled best. Current procurement legislation for governmental organisations like this Municipality, demands some form of public tendering and the leading question was how to safeguard without any doubt and under all circumstances the pursued IEQ in that process.

However, the subject of IEQ is not a single one in itself. It is a two-layered matter. First of all it is a matter of technical specification of the IE performances according to common professional standards and the assessment after the completion stage, whether or not these performances in reality are met. That is essentially an issue of private law (the project contract). Secondly, the other real life matter is the perception of the building's occupants regarding the IEQ.

The professional building owner and his IEQ consultant were and are driven by the desire to achieve the best possible results and go through a great deal of trouble to achieve a healthy indoor environment.

Generally in new build situations, in renovations or transformations, sufficient care about impressive IEQ results is not quite so obvious. The building process, from initial scoping and designing to procurement, construction, completion and post occupancy care, is subject to substantial changes, most of these being market changes. Which driving forces affect good IEQ and how can this quality be assured with due regards to the interests of the occupants? And, who really takes care about that?

## 2 OCCUPANTS

Efforts of professionals to make a healthy building, either new build or existing, either office, school, hotel or laboratory and such, should be aimed at keeping *people*, the occupants, healthy, satisfied and also productive. Whether or not they succeed to a considerable extent can for example be found in the (measurable and calculable) Perceived Percentage Dissatisfied (PPD), known from the thermal comfort theory of Fanger<sup>[1]</sup>, 1970. In reality building and workplace related non-wellbeing is predominantly expressed by people in the form of subjective complaints. It is based on a complex of perceptions, which covers more than thermal comfort alone, in fact the entire indoor environment, and is also entwined with non-physical influences of the entire work environment (Bluyssen et al.<sup>[2]</sup>, 2011, tabel 3; Bluyssen<sup>[3]</sup>, 2014, table 6.5).

The Dutch Centre for People and Buildings (CfPB), making knowledge about people, work and work environment applicable for companies and organisations, conducts since 2007 Post Occupancy Evaluations (POE) by means of benchmark studies into office users' average (dis)satisfaction with the most important aspects of their work environment. A standardized questionnaire from their WODI-tool<sup>[5]</sup> is being used. The benchmark is called *CfPB Indicator*, is not only updated annually, but is also growing steadily. The latest issue, released in 2016, is based on 134 different studies with 22,410 respondents from 52 different organisations.

The sub-benchmark CfPB *Flex* Indicator, a development of only recent years, about flexible offices, also called activity-related work environments, is growing too. In the 2016 issue, 68 such cases (12,395 respondents) during 2015 were covered.

Figure 1 presents the results of the Flex Indicator 2016<sup>[4]</sup>:

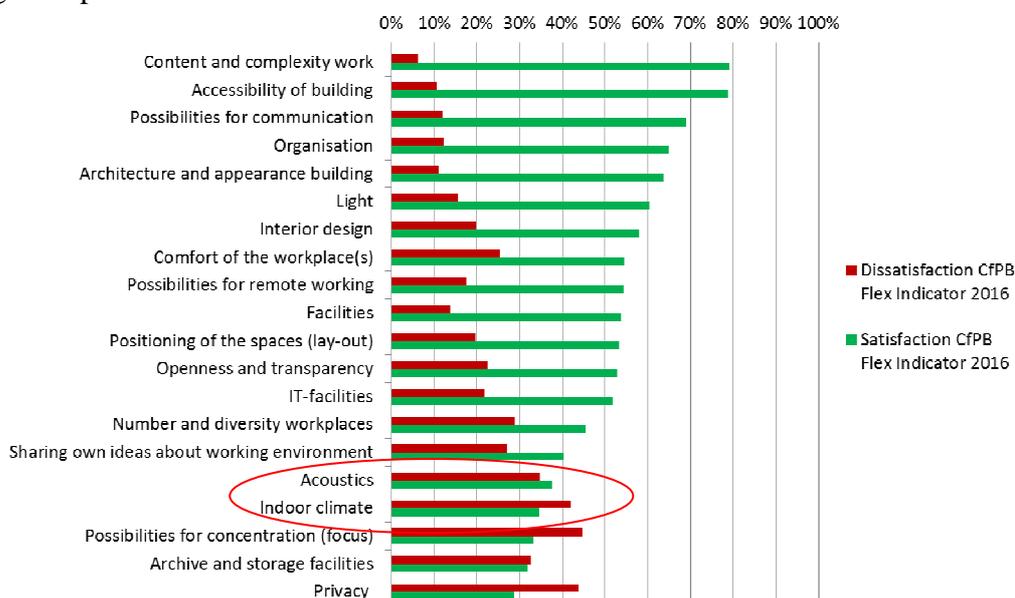


Figure 1: CfPB Flex Indicator 2016: the average percentage of respondents (very) satisfied or (very) dissatisfied with work environment aspects. Respondents who replied "neutral" are not shown in the figure.

The lower part of the graph shows the biggest problems people experienced. These are: privacy, filing and the archive, concentration possibilities and **indoor climate and acoustics**. The latter parts are a major cause of concern for everybody involved in IEQ matters. A breakdown of IEQ indicators (Maarleveld et al.<sup>[5]</sup>, 2009, figure 3), shows worrisome figures. A condensate is presented in table 1:

| Table 1                      | CfPB Indicator (Very) Satisfied (%) | CfPB Indicator (Very) <b>Dissatisfied</b> (%) | Design objectives EN-15251; <b>Dissatisfied</b> (%) |
|------------------------------|-------------------------------------|---|---|
| Temperature                  | 18                                  | 42  | < 10  |
| Draught                      | -                                   | -   | < 20  |
| Personal temperature control | 6                                   | 75  |   |
| Ventilation                  | 18                                  | 64  | < 20  |
| Air Quality                  | 22                                  | 55  |   |
| Artificial light             | 60                                  | 18  |   |
| Personal light control       | 23                                  | 63  |   |
| Acoustics                    | 32                                  | 23  |   |
| Noise from HVAC              | 42                                  | 23  |   |

According to occupants, IE belongs to the top important aspects of the work environment (Maarleveld et al.<sup>[5]</sup>, 2009, figure 4), second in ranking. How can it be that IE, which manifestly is considered a highly important issue, scores so very low?

### 3 DESIGN STANDARDS

Input for performance specifications regarding Perceived Percentage Dissatisfied can be derived from common practise design standards like EN-ISO-7730, EN-13779 and EN-15251 among others. The indoor climate is shown in 4 categories, Cat. I with the highest to Cat. IV with the lowest overall performance *expectations*. Cat. II, for the mainstream normal performance office buildings for example, shows design objectives in the area of

*temperature perception* like no more than 10% Dissatisfied, of *draught* less than 20% Dissatisfied and in the area of *air quality* (ventilation) no more than 20% Dissatisfied. Compare those figures to the CfPC Indicator and a huge gap, *the IEQ-gap*, is visible. This all is information of a general nature and rather detached from the situation in a specific building, but the IE specialist should be aware of the gap, not in the least make others aware and should in each project do his utmost to bridge the gap.

#### **4 BUILDING PROCESS**

The end result of what is supposed to be a healthy building for many years to come, is rooted in the design and construction process. The quality of that process and that of the participating professionals is key to the occupants' satisfaction level. In essence the design and construction process is a matter of private contractual achievement. Put simply, a building owner wants a new building and engages parties to produce that building within a certain scope, time and cost. Indoor Environment is a substantial aspect of that achievement and must have a beginning (scope) and an ending (delivery) in a contractual sense. In reality IE has two beginnings and two endings (in a legal sense this does not exist though). This in contrast to the construction part of the building, which has one beginning and one end. Why is that?

Construction is basically a static process, ending when the building is physically completed; generally without the furnishings and entire upholstery of the interior. At what is legally considered the completion date, formal documents are signed and the building is handed over to the owner. The building is ready for the move-in of the occupants and is considered to be operationally ready for use.

The guarantee period for the building part is limited and allows at first instance for time to remedy shortcomings. The Indoor Environment is a different matter. HVAC installations are indeed installed and commissioned, the latter if not squeezed to a minimum by the planning process, but these find in the completion date not an ending, but a new beginning. The installations may be operationally ready for use, but being in a state of marriage with the building envelope, the occupants and their equipment, only once the occupants have moved in, these installations start performing. It takes at least three full years<sup>[6]</sup> for all those involved to become aware of to what extent the IE performance requirements are met. The first year everything is new to the occupants, so attention goes out to many new aspects of the accommodation. Seasons pass and the following years one is more aware of the physical working conditions and the IE performance and generally more complaints can be expected.

However, practise shows that in the majority of building projects, almost all parties concerned consider the completion date as the end of the exercise and loose their direct interest. The facility manager, when faced with occupant complaints regarding the IE, passes these on to the installation contractor. In most cases a mechanic appears at the scene and does some adjustments, either mechanical or electronic, whatever seems to be effective. It does not require much imagination, that with the increasing sensitivities of buildings to indoor and outdoor conditions and the complexity of HVAC installations and their electronic control systems, the handling of occupant complaints requires expertise of a different nature; different from that for maintenance purposes. The expertise of an engineer, who has been involved during the design and the construction processes, is in fact indispensable.

Common assessment and intervention practise, related to IEQ matters, is complaint driven. Remarkable is the complete lack of objectivation by means of relevant measurement or monitoring, not only as a response to complaints, but also as planned post completion and post occupancy evaluation. The generally held view is that sufficient insights can be derived from the information from the building control system, but in particular the individual room controllers provide no more than the simple air temperature, perhaps the relative humidity and, only in case of volume controlled ventilation systems, also the CO<sub>2</sub>-level. That is all. No chance one can assess the operative temperature, let alone the thermal comfort from it,

nor the draught level, nor radiant asymmetries, nor VOC's, nor particulate matter levels, nor lighting or noise levels. The advancing IoT sensor applications are not much different in their measurement poverty, however popular these seem to be.

Another remarkable practise is that after the guarantee period, there is generally no formal ending, in which is established to what extent the contractual performances are indeed met.

The guarantee period remains to be seen as useful for the remedy of shortcomings, but in case of IE there is no question of shortcomings. To start with, it is only a matter of proving performances under design conditions.

Apart from the formal ending, let us suppose that objectifying measurements and monitoring in the post completion and post occupancy stage support a compliance with the earliest contractual objectives, however, when an organisation is subjected to a benchmark study like the CfPB one, it is very well possible that the collective perception of the occupants leads to a lower rating of the Indoor Environment, than objectively demonstrated.

The two step completion of IE related systems, in particular the second step, remaining unseen by many parties involved, deserves, rather demands much more attention. In fact it should be embedded in contracts much better than now is the case. In present public and private building law the focus lies only on shortcomings and (hidden) defects after the 'first' completion date. In case of IE, the building and its systems first have to prove the conformity with the initial requirements, before even shortcomings and/or defects are to be considered.

A shining example of how it should be approached is British BSRIA's *Soft Landings* concept<sup>[6]</sup>, with a wider scope than IEQ though, offering a platform of targeted knowledge and tools for solving the performance gap between design intentions and operational outcomes.

## 5 PROCUREMENT PROCESS

The way the building process is orchestrated is of influence on IE performances. The key factor is the positioning of the IE specialist, mostly the Building Services consultant, in the design and project management team. Preferably at the earliest stage, when building owner's requirements, including performance specifications, are written. In the classical situation, the building owner surrounds himself with the following independent knowledge parties, serving his interest:

- \* Project manager, Cost Consultant, Lawyer
- \* Architect, Structural Engineer, *Building Services Consultant / IE specialist*, Building Physics Consultant, Specs writer, Building Inspector/Supervisor

With the help of the project manager the different specialists are selected and the design team is put together.

Classical competitive construction tendering leads to the engagement of either a general contractor with mechanical (HVAC), electrical and other sub-contractors under his wings, or leads to separate building, mechanical and electrical contractors in the position of associate contractors, with the building contractor playing a leading and co-ordinating role. Of course there are quite a few variations on this concept. In the classical process the IE specialist is usually the guarantor of the IEQ by his involvement during the entire process, from scoping to the after care and the second level completion at the end of the guarantee period.

The building process however and its participants are subject to substantial changes due to market dynamics and the challenging ideas about procurement and the roles of the different stakeholders.

Advancing new procurement procedures, from Design & Build to Best Value, have in common that the roles of building owner, architect and consultant/specialists to a greater or lesser degree are reduced and the role of what is called "the market" is enlarged. The idea is that market participation is substantially more effective and cheaper in the end. If this works out that way for the realisation of buildings can be debated, but the fact is, that these procedures are quite popular. Interesting aspect is that some of these procurement concepts,

rather their followers, state that professionals like architect and consultants, supporting the building owner, are not at all needed any more, not even at the earliest briefing and scoping phase. The market (read: competing building contractors) is simply asked to offer a building, on the basis of the skinniest possible briefing. The specialists are replaced by a procurement consultant, who now has put himself in a key position during the entire scoping, designing and building process, from beginning to end (again: which end?).

In that process, the complex subject of Indoor Environment is by competing general building contractors passed on to competing mechanical and electrical sub-contractors. Since the front-line competitors are all dominated by building specialists, essentially focused on manufacturing, which is constructing in this case, with hardly substantial knowledge of or experience with the Indoor Environment science application and the integrated design of HVAC installations, the gnawing question presents itself: *who cares about IEQ?* Who, on the side of the building owner, makes sure that common IE requirements are specified at the earliest possible stage and that the results are finally checked by some form of objectivation? Who is responsible for bridging the IEQ-gap? And most importantly: who really cares about the wellbeing of the occupants?

Apart from knowledge, experiences and business culture in the past, related to IE in the widest sense, there is another pressing concern about all this and that is the considerable amount of experienced specialists at all levels leaving the field due to dismissal or retirement. Worrying also is the dramatic shortage of younger, well educated, but sufficiently experienced staff, due to the past economic crisis. Building and installation industry are already suffering from a huge expertise gap, which for IEQ, not at all being given the highest priority by building industry, certainly not in the new procurement settings, could have serious consequences in the future.

## 6 CONCLUSIONS

A healthy building or rather the health, wellbeing and productivity of people inside a building, is a subject of great significance, much studied, written and talked about. One mainstream of knowledge leads to design standards, which, for decades, IE specialists refer to and apply. An other mainstream is the outside-in surveys among large populations of occupants about the many aspects of the work environment, including IE.

In between sits the building project, subject to strong forces of non-technical nature and subject to an increasing lack of knowledge and experience by many parties involved.

Stronger than ever the IE specialist should make it his or her mission to *conquer* a place at the project table, *from the earliest possible moment on and during the entire realization process*, and to take firmly care of the occupants' interests. Moreover reduce, rather close the IEQ-gap!

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