Noise exposure ‘the new secondhand smoke’ - How is it addressed in building certification schemes

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Abstract.

(introduction) Building certification schemes have expanded to include both the environmental impact of the construction and operation of the building, as well as the building's influence on the occupants. Drawing attention to the indoor environmental quality, thus the well-being of the occupants, means evaluating a building's impact on all 5 of the human senses. Hearing, acoustics, can easily be overlooked, but distracting sound can affect our bodies in more ways than we may realize.

Buildings that provide a pleasant indoor acoustic environment, allow employees to be more productive, students to learn easier and hospital patients to recover quicker. A survey concluded that 75% of office employees list noise as an important workplace feature, yet only 30% are satisfied with the noise levels in their office. In schools, up to 70% of the consonants spoken by teachers cannot be heard by pupils.

A survey of the countries in the EU, requested by the EC, showed that 80% of respondents believed that noise affects their health, either to some or to a great extent. Additionally, noisy environments increase physical and mental risks for example hypertension, diabetes, and obesity. As such, it links to SDG 3 “Ensure healthy lives and promote well-being for all at all ages”.

(method) An analysis of the specific room acoustic requirements for open offices, which is the biggest building segment for green building schemes, and schools is the key component of the study. The analysis compares the quantitative requirements such as reverberation time and absorption area in 4 schemes (LEED, BREEAM, DGNB and WELL) to 8 national building regulations in Europe. As the building regulations only exist in their national languages these in depth comparisons are not common.

(results & conclusions) This comparison shows that several schemes do not require the anyhow legally required thresholds whereas few schemes go beyond.

1. Introduction

Everywhere in the world there is sound and unfortunately also noise. A survey among citizens of the EU showed that 80% of respondents, around 400 million people, believed that noise affects their health, either to some or to a great extent$^{[1]}$ (WHO, 2018). In 1905, the Nobel Prize-winning bacteriologist Robert Koch wrote, “The day will come when man will have to fight noise as inexorably as cholera and the plague.” Now, 115 years later, noise exposure is the new secondhand smoke$^{[2][3]}$ (Fetterman, 2018; Hearing Health Matters, 2018). We all know how secondhand smoke from tobacco affects our health. It causes cancer, heart disease and cardiovascular effects$^{[4]}$ (Centers...
for Disease Control and Prevention [CDC]). And exposure to unwanted noise can cause hearing loss\textsuperscript{[5]} (Mayes Jan L., 2019), tinnitus\textsuperscript{[6]} (WebMD, 2019), hyperacusis\textsuperscript{[7]} (ASHA, 2015), cardiovascular disease\textsuperscript{[8]} (Münzel T. et al., 2018) but also; stress, anxiety, insomnia, high blood pressure and increased heart rate\textsuperscript{[9]} (Healthy Hearing, 2019). For all these reasons it is important to be aware of the noise impact and take safety measures for a proper sound reduction.

1.1 Improving the indoor environment
So we can conclude that noise has a huge impact on our health and daily life. But how do we spend our lives? About 38% we are sleeping and about 24% of a typical working period of 50 years we are working\textsuperscript{[10]} (Gemma Curtis 2017). And with a globally life expectancy in 2019 of 73 and in Europe of 79 years\textsuperscript{[11]} (Roser M. et al., 2019) we are working, on an average, about 100.000 hours over a lifetime\textsuperscript{[12]} (Jessica Pryce-Jones, 2010). So if we can improve the indoor acoustic environment of the workplace we can improve people’s lives. And as such, it links to the UN Sustainable Development Goals (SDG) 3 "Ensure healthy lives and promote well-being for all at all ages". A healthy indoor and outdoor environment is one of the key topics in SDG 3.

2. Impact of indoor acoustic environment in offices
In this section we will focus on the specific room acoustic requirements for open offices, which is the biggest building segment for green building schemes. The use of open offices is very common in an office building anno 2020. With the growing number of open offices, the issue of acoustics is also growing. As Søren Peter Lund, a senior researcher at the Danish National Research Centre for the Working Environment explains: "The lack of privacy in an open office makes workers feel like they are constantly being watched, and the noises around them might be perceived as a threat and an intrusion. Especially when people are talking around you it becomes very difficult to concentrate. The acoustic quality of a room is one of the main factors to take into account when designing spaces that are used for both communicative and cognitive tasks"\textsuperscript{[13]} (Rockwool, 2018). In a survey conducted by the Leesman Index, 76% of office workers list noise as a crucial workplace consideration, with a catastrophic average satisfaction score of just 30%\textsuperscript{[14]} (Leesman Index, 2019). When office workers are disturbed by the noise due to bad acoustics, 34% try to find quieter place in the office\textsuperscript{[15]} (Poly, 2019). By creating a workplace environment with good acoustics and reducing distracting sound elements, a number of benefits can be observed in the office\textsuperscript{[16]} (Sykes, D M., 2004):

- 48% increase in employee focus
- 51% drop in employee distraction
- 10% fewer errors made
- 27% reduction in stress level

When designing an office interior: The acoustical environment of the office must be designed and integrated with the other architectural systems and furnishings of the office. Special consideration must be given to noise control in open office settings, with absorptive finish materials, masking white noise, and sufficient separation of individual occupants\textsuperscript{[17]} WBDG (2017).

2.1 Acoustic regulations and recommendations of office buildings
You would think, to improve the indoor acoustic environment, that every country has its own national standards, regulations or recommendations. But unfortunately that is not the case.
Also Building certification schemes have expanded to include both the environmental impact of the construction and operation of the building, as well as the building's influence on the occupants. Drawing attention to the indoor environmental quality, thus the well-being of the occupants, means evaluating a building's impact on all 5 of the human senses. Acoustics in open-plan offices is often described by the Reverberation Time (RT) in seconds and since a few years by the parameters of the international standard ISO 3382-3:2012\cite{18};

- Spatial decay rate of speech (D2,S) in dB
- Distraction distance (rD) in metres.
- Average a-weighted background noise (Lp, A, B) in dB
- A-weighted SPL of Speech at 4 m (Lp, A, s, 4m) in dB
- Privacy distance (rP) in metres

The reverberation time has been proven insufficient in addressing speech privacy issues due to its temporal nature. But lately also questions are rising if the ISO 3382-3:2012 standard is sufficient enough\cite{19}. That is why we will compare the Reverberation Time from the existing national standards ‘table 1’, and the different green building certification schemes, ‘table 2’, because most of them use this parameter.

### 2.1.1 National standards

#### Table 1. comparison of different national standards

| Country | Reverberation Time | Comment | Source |
|---------|--------------------|---------|--------|
| Germany | ≤ 0.6 sec.\(^{(1)}\) | Room Acoustics Class A Big open-plan office | VDI 2569:2019-10 |
| Norway  | ≤ 0.45 sec.\(^{(2)}\) | Sound quality class C; 0.16 x h (h = ceiling height). Using h = 2.80m | NS 8175 2012 |
| Sweden  | ≤ 0.40 sec.\(^{(2)}\) | Sound class C; Open office (>20 people) | SS 25268 2007 |
| Denmark | A > 1.1*floor area | Absorption area (A) for multiple person offices | Bygningsreglement 2018 (BR18) ⇒ Lydforhold (§ 368 - § 376) Vejledning |
| Netherlands | ≤ 0.5 sec.\(^{(3)}\) | ≤ 0.5 furnished, ≤ 0.6 unfurnished | Handboek Bouwtechnische Kwaliteit Gebouwen (d.d. 23-03-2018). Page 65-73 |
| Finland | ≤ 0.6 sec.\(^{(2)}\) | Open-plan and activity-based offices | 796/2017 Decree of the Ministry of the Environment on sound insulation and noise abatement in buildings” |
| Poland  | ≤ 0.6 sec.\(^{(1)}\) | Open-plan offices | PN-B-02151-4: 2015-06: Building acoustics - Protection against noise in buildings - Part 4: Requirements for reverberation |
| France  | ≤ 0.6 sec.\(^{(1)}\) | Open-plan and activity-based offices | NF S 31-199 (2016) |

Average freq. range 1/1 octave band; (1) 250-4000Hz, (2) 125-4000Hz, (3) 250-2000Hz.
2.1.2 Green building schemes

Worldwide there are almost 50 Green Building Schemes, ‘figure 1’. In this section we focus on the four most used\cite{20} (Guide to Sustainable Building Certifications, 2018); the Leadership in Energy and Environmental Design (LEED) present in 164 countries, the Building Research Establishment Environmental Assessment Method (BREEAM), present in 77 countries, the WELL Building Standard™ present in 32 countries and the German Sustainable Building Council (DGNB) present in 21 countries.

![Figure 1](image_url): World map building certifications and their origin location

| Building scheme | Reverberation Time | Comment | Source |
|-----------------|--------------------|---------|--------|
| BREEAM          | 0,90 sec.\cite{4}  | 1000m³ room volume; At 500 Hz, unoccupied rooms | BREEAM International New Construction 2016; Hea 05 Acoustic performance |
| LEED            | 0,80 sec.          | at 500 Hz, 1000 Hz, and 2000 Hz | LEED V4 for Interior Design and Construction; EQ Credit: Acoustic performance |
| WELL            | V1: 0,50 sec.      | V1: NRC of 0.90 for 100% of ceiling; V2: NRC of 0.70 for 75% of ceiling | WELL v1 category Comfort, Feature 78: Reverberation time; WELL v2 category Sound, S04 Sound Absorption, Part 1 |
| DGNB            | ≤ 0,60 sec.\cite{5} | Multi-person offices larger than 40 m². Compliance with German VDI 2569 | DGNB criteria "Acoustic comfort" (SOC1.3) |
|                 | ≤ 0,70 sec.\cite{6} | | |
|                 | ≤ 0,90 sec.\cite{7} | | |

(4) depending on room volume, (5) 30 certification points, (6) 20 certification points, (7) 10 certification points
3. Conclusion

To "Ensure healthy lives and promote well-being for all at all ages" (SDG 3) a good indoor acoustic environment is essential. Some building certification schemes say the pay a contribution or even override the SDG3 sustainability goals (DNGB, 2018). Green Building Certification Schemes have >1 billion m2 certified and are expected to grow. But room acoustics requirements in schemes are today not a prerequisite and can be completely ignored. Based upon the comparison presented in this paper it is clear that the room acoustic requirements in schemes are often below the ones in the national standards. Question is: why? Are the office buildings getting too expensive with stricter requirements? Or is it too difficult to comply with all the different national standards in the countries where they are present? More research is needed to get answers on these question. A suggestion could be that the ambitious classes in ISO (or EN) standards on acoustic classification of buildings would be the key reference for schemes.

4. References

[1] WHO Environmental Noise Guidelines for the European Region 2018 http://www.euro.who.int/data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf

[2] Fetterman, M. (2018). Noise exposure is becoming ‘the new second-hand smoke.’ The Washington Post, May 12, 2018.

[3] Hearing Health Matters (2018). https://hearinghealthmatters.org/hearingnewswatch/2018/noise-pollution-new-secondhand-smoke/, April 10, 2018

[4] Centers for Disease Control and Prevention [CDC] https://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/general_facts/index.htm

[5] Mayes Jan L. (2019). Urban noise levels are high enough to damage auditory sensorineural health

[6] WebMD (2019) Medical Reference, reviewed by Minesh Khatri, MD on Nov. 12, 2019

https://www.webmd.com/a-to-z-guides/understanding-tinnitus-basics

[7] Sharon Goodson, ASHA (2015), MA, CF-A, Palo Alto Medical Foundation and Raymond H. Hull, PhD, Professor of Communicative Disorders and Sciences, Audiology, Wichita State University https://www.asha.org/uploadedFiles/AIS-Hyperacusis.pdf

[8] Münzel T. et al. (2018) Environmental Noise and the Cardiovascular System, Journal of the American College of Cardiology Volume 71, Issue 6, 13 February 2018

[9] Joy Victory (2019), Healthy Hearing, Oct. 21, 2019, https://www.healthyhearing.com/help/hearing-loss/noise-induced-hearing-loss

[10] Gemma Curtis, Dreams Ltd, Your Life In Numbers, https://www.dreams.co.uk/sleep-matters-club/your-life-in-numbers-infographic/

[11] Max Roser, Esteban Ortiz-Ospina and Hannah Ritchie, October 2019, Life Expectancy, https://ourworldindata.org/life-expectancy

[12] Jessica Pryce-Jones, Book: Happiness at Work: Maximizing Your Psychological Capital for Success, February 19, 2010

[13] Rockwool Group, The office that sounds as peaceful as it looks, 2018 https://www.rockwoolgrouop.com/our-thinking/urbanization/acoustics/

[14] Leesman Index (2019): The Workplace Experience Revolution Part 2, Second digital edition.

[15] Poly survey (2019), "All your employees are distracted- The realities of today’s open office and what you can do about it", Plantronics Global survey of 5.151 office workers across 10 countries.

[16] Sykes, David M., PhD, 2004, “Productivity: How Acoustics Affect Workers’ Performance in Open Areas”

[17] Brian Conway (2017), WBDG The Planning Site, LLC, December 5, 2017 - Whole Building Design Guide® https://www.wbdg.org/building-types/office-building

[18] ISO 3382-3:2012 Acoustics, Measurement of room acoustic parameters, Part 3: Open plan offices

[19] Jack Harvie-Clark1, Felix Larrieu1, Cecile Opsanger2,(2019)'Apex Acoustics Ltd. UK, 'Multiconsult Norway, ISO 3382-3: Necessary But Not Sufficient. A New Approach To Acoustic Design for Activity-Based-Working Offices, ICA 2019 Aachen.

[20] Guide to Sustainable Building Certifications, Published by SBi and G2X, August 2018, ISBN 978-87-563-1881-5

[21] DGNB system – New buildings criteria set version 2018, criteria "Acoustic comfort" (SOC1.3)