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Office Environments: Parameters for comfort in Europe vs. US

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Abstract

Problem Definition
Well-designed office environments can sustain satisfaction, health and performance of employees. Therefor environmental factors influencing human wellbeing and performance are defined in laws and standards. But these regulations are mainly country specific and cannot easily be compared. EU-legislation and standards led to the adaption of country specific regulations, but there are still many differences and varying priorities. If international enterprises and organizations develop corporate office environment concepts, they have to consider these local differences. So the intended audience of these results are Facility Managers of international companies and workplace consultants who want to roll out workplace concepts worldwide. Regulations in Europe are compared to regulations in the USA to show the state of the art. The question is, if these different regulations demand for different solutions.

Method
As first step, about 100 laws, guidelines and standards on indoor environmental climate from WHO, EU and USA were evaluated. Based on literature research the relevant areas were defined. To set up a common model, room categories had to be defined and the requirements for these room types were gathered. Climate-parameters were classified with the following topics: Thermal Comfort, Indoor Air quality, Lighting and Acoustics. The newly formed common model provides the basis for a comparative study.

Result
The result shows key aspects, priorities and differences of criteria for health and comfort for different countries. When rolling out a workplace concept internationally these local regulations have to be taken into consideration. Key factors are presented, how local regulations can have an effect on office design, comparing European countries and the US.

Keywords: international standards, occupational health, office environments, room climate

Introduction

Research from the last decades shows, how much health and performance in office environments is influenced by room climate parameters. Thermal comfort, indoor air quality, lighting and

acoustics are relevant topics for health, wellbeing and performance (i.e. Bischof, 2003). The question is, if the definition of room climate parameters in laws and standards is different in Europe and the USA. If standard values are different, this might have impact on the design of office environments. The introduction gives a short overview with basic knowledge on relevant room climate parameters and how they are defined.

Climate Parameter Definition

The European standard EN 15251 defines indoor environmental parameters for design and assessment of energy performance of buildings. According to this standard the parameters were structured in Thermal Comfort, Indoor Air Quality, Lighting and Acoustics.

Thermal Comfort

Fangers Model of the Predicted Mean Vote

Thermal comfort is influenced by various factors. Laws and standards refer in most cases to room temperature, air velocity and air humidity. Thermal comfort depends also on personal factors as sex, age, clothes, activity level or season. (Fanger, 1970). Fangers Model for thermal comfort is still the basis for standards on room climate worldwide. The Danish scientist Ole Fanger developed in the late 60ties the model of the predicted mean vote (PMV). The PMV describes the predicted mean thermal perception of building occupants, considering personal factors. European (ISO 7730) and national standards as well as ASHRAE-standards (ASHRAE Standard 55) are based on the PMV-Modell.

Indoor Air Quality

Harmful Substances and Radiations

The ingredients of the indoor air define the quality of the indoor air. An additional influence factor is radiation. Harmful substances and radiations can have a bad impact on health, wellbeing or performance. Therefor the content of harmful substances and radiations is regulated in labor legislation.

Carbon Dioxide (CO_2) as Indicator

Odor is another important influence factor, but it is difficult to measure. Odor is not connected necessarily to harmful substances. Odor can be very annoying, even if it is not harmful to health at all, i.e. food odors in an office environment. The concentration of CO_2 in the indoor air is an indicator for odors, human emanations and some other volatile organic substances. Limit values for CO_2 make odors measurable up to a certain point.

Further the concentration of CO_2 influences human performance. This observation dates back to the 19th century to the German hygienist Pettenkofer, who defined the concentration of 1000ppm CO_2 as threshold value for comfortable air quality. This value has been confirmed in various investigations (Shaughnessy, 2006) (Redlein, 2014).

Lighting

Daylight:
Natural lighting is a benchmark for everything in the field of lighting. The changing light in the course of the day and the year is essential for the human circadian rhythm. Light influences metabolism, blood circulation, hormonal balance, immune system and mental factors. (SECO, 2014). Tab. 1 shows the relation of typical light parameters for daylight and for office environments.

Table 1. daylight as benchmark for light parameters

	Daylight (erco, 2013)	**Artificial lighting**
Illuminance	overcast sky: 10.000 lux	office: 500 lux (erco,2013)
Light Temperature	5000-6000 Kelvin	light bulb: 2700-2900 Kelvin (EN 12464-1)
Color Reproduction Value	$R_a = 100$	operation theatre: $R_a = 90$ (DIN 5035-3)

Acoustic

Disturbing Noise
Noise can be defined as disturbing sound. Sound can be measured by volume, frequency and rhythm. (Fasold, 2003) If sound is perceived as disturbing depends not only on these factors. The sound of a mosquito can be very disturbing, although it is nearly inaudible. Music, ocean sounds, birds singing can be much louder and can support concentration or creativity- but not for everybody in every situation. What are the legal requirements in this case?

Noise Exposure vs. Speech Intelligibility
Legal requirements distinguish between the background sound level of a room and the noise exposure level for workers (i.e. VOLV,2008; VDI 2058). The background sound level of an office room is determined by factors as heating, ventilation, air conditioning or office machines. The noise exposure level for workers regulates the maximal allowed sound pressure. Factors for a good work environment are the listening conditions and speech intelligibility. The speech intelligibility depends on the noise level inside the room and on the absorption and sound reflection of the surrounding surfaces. The reverberation time gives a measure to determine the speech intelligibility inside a room (DIN 18041).

Method

Review of Laws and Standards

The first step for this study was an extensive review of laws and standards to identify relevant room climate parameters. The European standard EN 15251 gave orientation to structure the parameters. The evaluation of laws and standards took place from March 2015 to August 2015; in total more than 100 laws and standards were evaluated, resulting in about 1700 requirements.

Europe
To cover entirely the Austrian building law, the Austrian federal legal information system and the Austrian Standards Database were the search platforms to start with. Overarching international institutions as EU, ISO and WHO (World Health Organization) were added. Swiss and German laws and standards were added, to compare the German speaking countries in the DACH-region (DACH stands for D-Germany, A-Austria, CH-Switzerland

USA
The occupational safety and health standards in the USA (OSHA) give some basic requirements for office workers. The USA does not have official national building codes, but each state or local government adopts codes, which are developed by recognized organizations (i.e. ASHRAE). Because of this, there is little uniformity among the regulations in different states (EPA). The study refers to the most common standards.

Making Parameters Comparable
Room parameters are defined differently in different laws and standards as well as in different countries. The same problem refers to the clustering of the related rooms. To make the room climate parameters comparable, two areas had to be consolidated:

- Common parameter definitions
- Common room types

In the study climate parameters were selected in the following way: Room parameters had to define the conditions inside a room, not the physical characteristics of the surrounding structures and not technical values for devices (i.e. air condition).
Temperature, Air Humidity and Air Velocity were chosen as influencing parameters for Thermal Comfort. To compare Indoor Air Quality, CO_2-concentration was taken into account. Chemical agents were evaluated by their concentration in indoor air. Tobacco Smoke was included by comparing if smoking in workplaces is allowed or not. Lighting parameters included natural lighting and views as well as artificial lighting. The relevant parameters for lighting were Illuminance, Light Temperature and Color Reproduction Factor and effects as Glare or Shadows. Noise level in db(A) and Reverberation Time were the relevant parameters for Acoustics.
The definition of room types is often related to area measurement standards. Room types in the database are based on ÖNORM B1800:2013. The area measurement in this Austrian Standard is according to the European standard for Facility Management (EN 15221-6).

Results

The result is a comparison of relevant room climate parameters in respect to office environments between different EU-countries and the USA.

Thermal Comfort

Temperature, Air Humidity and Air Velocity
Differences can be found in the valuation of air humidity and air velocity as influence factors. Regulations are binding in some countries, while in others they can be seen more as a recommendation. The American ASHRAE Standard 55 gives recommendations on temperatures, depending on air humidity. In contrast to this, the European ISO 7730 focuses on the dependency

of thermal comfort on air velocity; the influence of air humidity is described as insignificant for temperatures under 26°.Table 2 gives a short overview:

Table 2. recommended air temperature

	Air Humidity (%)	**Temperature (°C)** Temperatur (°F)	**Source**
USA	Summer: (light clothing) if 30%, then:	24.5-28°C acceptable (76,1-82,4 °F)	ASHRAE Standard 55-2010
	Summer: (light clothing) if 60%, then:	23-25.5°C acceptable (73,4-77,9°F)	
	General recommendation: 20-60%	20-25 (68-76° F)	OSHA
	Air Velocity (m/s)	**Temperature (°C)**	**Source**
Europe	Summer: (Cat.A) 0,12 m/s	23.5-25,5°C acceptable (73,4-77,9°F)	ISO 7730:2005

High Temperatures
The American OSHA recommends temperature control in the range of 20- 25°C, but this is not legally binding. For a valid complaint it would be necessary to prove that indoor air in a work environment is hazardous to the health of a building occupant. In Austria temperature is tolerable in a quite large spectrum between 19° and 25°C (66-76°F) (AStV), while there are no consequences when temperatures are higher. Germany has a risk assessment for higher temperatures (ASR 3.5). With room temperatures higher than 35°C (95°F) work is not permitted by law (ASR 3.5). In Switzerland there is also an action plan for high temperatures (SECO, 2015).

Indoor Air Quality

CO_2
CO_2 (carbon dioxide) is an indicator for indoor air quality. The recommended values for good air quality do not vary much. They are not legally binding. The Austrian Guidelines for Indoor Air Assessment (RL Luft) recommend a concentration of 600-1000 ppm as a standard mean value. EN 13779: 2007 defines the same value as a recommendation for moderate air quality.

Chemical Agents
With respect to legal regulations on occupational health, in all countries there is a kind of ordinance on the exposure to chemical agents (EU-directive 2003/10/EC). It sets out exposure limit values and preventive measures to protect workers from the effects of chemicals they may encounter in the course of their job. The emissions from materials and devices in the office environment are regulated in product regulations and guidelines for Indoor Air Assessment.

Tobacco Smoke
Legally binding regulations, concerning indoor air quality, can be found in the laws concerning tobacco smoke. In the USA each state has its own regulations. Surprisingly there are still some states, where smoking in workplaces is allowed, i.e. in North Carolina (nolo.com). The EU-council recommendation on smoke free environments (EU Council recommendation, 2009) asks local governments to provide effective protection from exposure to tobacco smoke. Currently, seven EU countries have a complete ban on smoking in workplaces.

Lighting

Natural Lighting and Views
The lighting topic affects workplace design very much. In Austria the view outside from each stationary workplace is mandatory. For this reason, the typical American cubicle workplaces could not be realized in an Austrian office. European EN 12464-1 gives not so many restrictions, but underlines the importance of natural light. The latest version of the American IES-Lighting handbook (IES, 2011) considers the integration of daylight and the effects of light on human health. The OSHA-recommendations consider only the negative effects of natural light, like too high brightness levels for computer work or glare effects.

Table 3. natural lighting

	Natural lighting	Source
USA	Integration of daylight is mentioned	IES-Lighting Handbook
USA	Only negative effects of natural light considered: i.e. glare effects	Occupational Safety and Health OSHA
Europe	Underlines the importance of natural light. Requirements for natural light are the same as for artificial lighting	EN12464-1
Austria	View outside mandatory from each stationary workplace. Window size at least 5% of floor surface of the room. Light domes or glass-roofs do not count for intervisibility.	Workplace Ordinance §28 (AStV)

Glare Effects
The EU-Council Directive on the minimum safety and health requirements for work with display screen equipment (90/270/EEC) regulates, that workplaces always have to be parallel to windows, to avoid glare effects on computer screens.

Acoustics

Noise-induced Hearing-loss
'Worldwide, noise-induced hearing-impairment is the most prevalent occupational hazard' (WHO 1999). Permanent noise exposure to more than 75dB(A) causes directly hearing loss (Concha-Barrientos, 2004). The OSHA-standards in the USA allow a permissible noise exposure of 90 dB(A) (OSHA 1910.95). The corresponding EU-directive (2003/10/EC) limits daily noise exposure levels with 80 dB(A). In office environments the noise exposure is usually much lower. The effects of lower noise levels are less evident and consequently there exist less legal requirements on lower noise levels.

Annoyance from Noise
Lower noise levels have effects on performance and wellbeing, even if this is still weakly supported by research evidence. The negative effects of lower noise levels are taken in account in laws and standards. Intruding steady-state noise is one criterion: The Unified Facilities Criteria (UFC 3-450-01) by the U.S. Department of Defence demand for a background sound level in the range of 30-35 dB(A) in private offices, in large offices 35-40 db(A) are tolerated. In Europe the EN 13779 demands for similar background sound levels.

Table 4. disturbing noise levels

	Maximum noise level db(A)	Source
USA	30-35 db(A) in private offices 35-40 db(A) in large offices	UFC 3-450-01
Europe	30 bis 40, Standard 35 in small offices 35 bis 45, Standard 40 in large offices	EN 13779

Conclusion

The comparison of standards on room climate in office environment shows, that standards in all countries consider similar aspects, but some differences have influences on workplace design. In European Countries more regulations are legally binding. Workplace design is regulated in labor law and is in detail still country-specific. Global enterprises develop corporate workplace design standards for office environments. Considering the local regulations i.e. on lighting demands in EU in the initial programming and standardizing process makes it easier, to roll out a concept in multiple countries. This is relevant for consultants, working in the field of workplace programming and design as well as for facility managers, leading a workplace concept process.

Outlook

To link this 'state-of-the-art'-knowledge on room climate with real office environments further case studies are planned, to verify the connection of health and performance with room climate factors. New ways of working have an important impact on workplace design. It is to prove, how these changes influence the perception of room climate factors.

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Dear Author,

Thank you for your submission to the IFMA A&R Track 2016, we appreciate your efforts! As a contributor, we would appreciate your peer review of the attached paper.

To make the review process more convenient, please submit your review online by clicking on the following link: http://goo.gl/forms/rLmMRMPncE

The double blind peer review process requires us to keep both authors' and reviewers' names anonymous.

In order to maintain the A&R Track schedule, we are requesting your complete review by **March 28, 2016**.

Thank you for your time and contributions. Please let us know if you have any questions.

Sincerely,

Editorial Coordinator

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Management Skills Learning Lab
Room: 2

4.12

Part 1: Understanding the User Workplace Experience

Speaker: Dr. Anita Kamouri

Part 2: What WE Learned at our Workplace Innovation workshop at Nike

Speakers: Mark Ellis, Nike; Kate North, PlaceValue

Workplace Strategies
300 Level

Leading & Bleeding Edge Learning Lab
Room: 1B

4.13

Smart Buildings: From HYPE to VALUE – Proven Impact from Real Cases

IWMS Solutions
300 level

Through a connected network of wireless, affordable meters, sensors and mobile devices, real estate managers can finally capture actual performance drivers. Learn how big data and technology can optimize building performance and space usage, workplace productivity and user experience. **Speaker:** Koen Matthijs, CEO, MCS

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Academic & Research Track Sessions

Room 16B, 2nd Level, SDCC

Thursday, Oct. 6

8:30 a.m. – 8:45 a.m.
Operating Resources & Carbon Footprints of Commercial Buildings: A Study in Hong Kong / Speakers: Joseph H.K. Lai; Seung Hyun Cha

8:45 a.m. – 9 a.m.
Energy Usage & Critical Occupant Behaviors in LEED Buildings / Speakers: Khalid Siddiqi; Stacey Flint

9 a.m. – 9:15 a.m.
Reduction of Peak Energy Demand Through Thermal Energy Storage / Speakers: Daniel Whitcraft; Kenneth Sullivan; Curtis Slife

9:30 a.m. – 9:45 a.m.
Sustainability in FM / Speaker: John Kim

9:45 a.m. – 10 a.m.
Towards Enterprise Application Integration Principles for Facility Management Software in Hospitals / Speakers: Nicole Gerber; Susanne Hofer; Nazali Mohd-Noor

10 a.m. – 10:15 a.m.
Technological Advances in the Facility Management Profession / Speakers: Charles Petrinovich; Clifton Farnsworth; Michael Bown

10:15 a.m. – 10:30 a.m.
A Systematic Look at FM's Organizational Structure in Swiss Hospitals / Speakers: Franziska C. Honegger; Melanie Mader

10:30 a.m. – 10:45 a.m.
The Experiential Workplace / Speaker: Branka Olson

10:45 a.m. – 11 a.m.
Procurement Expertise in FM: A New Approach for Custodial Services Contracts / Speakers: Jake Smithwick; Kristen Hurtado; Brian Lines

12:30 p.m. – 12:45 p.m.
State of Practice for Building Condition Assessment / Speakers: Pauline Karanja; Glenda Mayo

12:45 p.m. – 1 p.m.
An Approach to Auditing the Functionality of Wheelchair Accessible Doors at Universities / Speakers: Michael Bown; Benjamin Costello

1 p.m. – 1:15 p.m.
Workspace Choice & Control in Office Settings / Speaker: Madalina Hanc

1:15 p.m. – 1:30 p.m.
Office Environments: Parameters for Comfort in Europe vs. USA / Speakers: Alexander Redlein; Christine Hax-Noske

2 p.m. – 2:15 p.m.
An Investigation of Stakeholder Views of a Facility Management Curriculum in South Africa / Speakers: Yewande Adewunmi; Oluwayomi Babatunde; Samuel Azasu

2:15 p.m. – 2:30 p.m.
FM Scholarship in the University Community: Building on Boyer & Schon / Speaker: Christopher L. Cosper

2:30 p.m. – 2:45 p.m.
An ROI Analysis of FM Credentials / Speakers: Kristen Hurtado; Jake Smithwick; Kenneth Sullivan

2:45 p.m. – 3:15 p.m.
Introduction of the Journal of Facility Management Education & Research (JFMER)