Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 78 (2015) 1641 – 1646

Energy Procedia

6th International Building Physics Conference, IBPC 2015

Acoustic measurements in retrofit buildings lead to a sustainable design of a (semi-) open plan office

Sara Vellenga-Persoon*, Theodoor Höngens

M+P Consulting Engineers, PO Box 344, NL-1430 AH Aalsmeer, The Netherlands

Abstract

Working in an office environment entails various activities. Communication on the phone, social interaction and meetings produce not only sound, but are also in need of a good speech intelligibility and therefore in need of good room acoustics. Difficult performance tasks are in need of different acoustic conditions. Areas with a more silent environment are needed with a minimised level of distraction from surrounding activities. Areas with a high level of interaction provide workspace for the purpose of teamwork. Different activities require unique acoustic conditions.

Before creating a new activity based design in retrofit buildings, the existing acoustic environment is carefully measured. The acoustic qualities of the existing facilities as well as the actual behaviour of the existing population of the building are both measured. The sound insulation of the existing walls is defined as A-weighted standardized level difference $D_{nT,A}$, measured according to the Dutch norm NEN 5077 (similar to ISO 140-4). The room acoustic parameters are defined by the reverberation time T, measured according to ISO 3382, and the spatial decay rate of A-weighted SPL of speech $D_{2,S}$ measured according to the norm ISO 3382-3 for room acoustics in open plan offices. The level of speech privacy is interpreted out of the combination of A-weighted sound pressure levels of speech $L_{p,A,S}$ and the average A-weighted background noise level $L_{p,A,B}$ per position. During a representative week of working hours the sound levels are being measured on different locations in the open plan office. The sound levels are measured in equivalent sound levels $L_{eq,\ 5min}$ and maximum sound levels $L_{max,\ 5min}$. To gather information about the character of the sound, sound fragments are also recorded based on a trigger level.

Defining the acoustic environment of (semi-)open plan offices based on building measurements and noise level measurements produces a solid foundation for designing a more sustainable office environment. Often the new design leads to activity based office plans where diverse activities are projected in a (semi-) open plan office. This is illustrated with a practical example of an engineering project.

Peer-review under responsibility of the CENTRO CONGRESSI INTERNAZIONALE SRL

Keywords: open plan offices; acoustic; retrofit buildings; activity based working

* Corresponding author. Tel.: +31-297-320-651; fax: +31-297-325-494. *E-mail address:* SaraVellenga@mp.nl

Peer-review under responsibility of the CENTRO CONGRESSI INTERNAZIONALE SRL
doi:10.1016/j.egypro.2015.11.243

1. Introduction

A sustainable design seeks to reduce negative impacts on the environment and aims to increase the health and comfort of building occupants. Acoustic comfort in the workplace is very important for a productive and satisfactory environment. The Leesman review of September 2014 [1] showed a high rate of dissatisfaction because of noise levels in the working environment. Out of about 55.000 employee, 47% of those surveyed found the noise level to be dissatisfying for an effective working space. Next to the feature 'temperature control', the sound related features for 'noise levels' and 'quiet rooms for working alone or in pairs' show the highest levels of dissatisfaction and the lowest of satisfaction. Defining the acoustic environment is an important part of the design process. Four questions should be asked:

- The first question is: 'What is the acoustic comfort in the existing situation?',
- the second question is: 'What is the ideal acoustic comfort aimed for in a new environment?'
- and the third question is: 'What is the best achievable level of acoustic comfort in the retrofit building?'.
- The final question is: 'What level of acoustic comfort is present after refurbishment with activity based design?'.

To find out about the best achievable level of acoustic comfort 'baseline measurements' are made and these results translated into reasonable target values for an optimal acoustic comfort in the situation of the retrofit building. In that way, a sustainable office environment is created to host a flexible, activity based working environment.

After the process of re-designing, renovation and refurbishment the actual level of achieved acoustic comfort can be evaluated by measurements again. The results of these 'control measurements' show in what degree the target values are being met in practice. Control measurements also enable a comparison between the 'before' and 'after' situation , evaluate the targets and to pair these to the comfort of the workplaces.

2. Investigation approach

Before creating a new activity based design in retrofit buildings the existing acoustic environment is carefully measured using several acoustic parameters. Measurements taken previously as baseline measurements show the level of acoustic comfort in the existing situation. The acoustic qualities of the existing facilities as well as the actual behaviour of the existing population of the building are both measured. General target values are set according to the Dutch Handbook Quality in Building Physics for Offices [2]. Specific target values are based on the experience of M+P. For setting specific target values the current situation of the existing building and special needs of an organization are taken into account.

2.1. Acoustical parameters building and room acoustics

The sound insulations of the existing walls are measured, the reverberation times are measured including present ceilings and furnishing and the spatial decay is being defined over several lines of decay in the open plan parts of the office. The noise produced by the existing HVAC system is determined by measuring the background noise level. The position of ventilation ducts is considered regarding the sound transmission over the ceilings.

The sound insulation of the existing walls is defined as A-weighted standardized level difference $D_{nT,A}$ (measured according to the Dutch norm NEN 5077 [3] similar to ISO 140-4 [4]). For meeting rooms with a high level of discretion a $D_{nT,A}$ of 42 or 45 dB is set as a target value and 33 dB including a wall with a door. For a closed office with a normal level of discretion a $D_{nT,A}$ of 39 dB is set as a target value and 27 dB including a wall with a door.

The room acoustic parameters are defined by the reverberation time T (measured according to ISO 3382 [5]). For a furnished open plan office a target value is set as a maximum of 0,5 s as a mean value of octave band 250 Hz to 2.000 Hz. For furnished closed cell offices the target value is adjusted to 0,6 s.

The spatial decay rate of A-weighted sound pressure level of speech $D_{2,S}$ is measured according to the norm ISO 3382-3 [6] for room acoustics in open plan offices. The level of speech privacy is interpreted from the combination of A-weighted sound pressure levels of speech $L_{p,A,S}$ and the average A-weighted background noise level $L_{p,A,B}$ per position. The Dutch handbook sets a target value of 5 dB within a cluster of working spots with the same activities and 11 dB between clusters of working spots with different activities. When the signal to noise SNR drops under 3