CETIEB

D6.2 Information about best measuring points for the sensors

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COOPERATION

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1 Introduction

1.1 Parameters for the estimation of the indoor environment quality

We spend most of the time of our life indoors. We construct buildings mainly to create comfortable and healthy microclimate for living. That is why it is very important to create inside thermal comfort, to provide good air quality and supply clean outside air necessary for the breathing and dilution of contaminations emitted into the room, to prevent mildew and appearance of other microorganisms.

Thermal comfort is influenced by the temperature of the air and its gradient over the room height, by relative humidity of the air and velocity of air movement. Because of the radiation exchange with the surroundings the temperatures of ambient surfaces also have an influence on the thermal comfort of the person. For information about acceptable values of the parameters, mentioned before, see deliverable CETIEB D2.2, or EN 15251:2007 [1] and EN ISO 7730 [2].

Indoor air quality changes because of the human breathing, because of the contaminations discharged during the cleaning or from interior decorations and the furniture.

While breathing person release water vapour, carbon dioxide and other gases. Carbon dioxide (CO_2) is usually used for the estimation of the air quality as a marker. Detailed information about CO_2 concentration indoor and classification of indoor air quality is given in EN 13779:2007 [3]. Review of various international normative documents is given in deliverable CETIEB D2.2.

In modern tight buildings it is also necessary to pay attention on concentrations of chemical contaminations emitted from indoor decorations, office equipment and household appliances. The main groups of chemical pollutants are:

- inorganic gases
- volatile organic compounds (VOCs)
- low-volatile organic compounds
- inorganic particles

For detailed information about the allowed concentrations of different pollutants depending on the exposure time see Deliverable D2.2.

Illumination influences the productivity and mood of the person. Information about light intensity required in different types of building depending on the room functions is provided in Deliverable D2.2.

1.2 Work zone (Residential Zone)

Figure 1-1 shows a typical room used mainly by people who are working or living inside this room. The work zone describes the whole volume of the room where people can stay normally. The rest zone describes the volume of the room which is normally not used by people (f. e. near the ceiling). The residential zone describes the near volume of the room around the person staying. It’s a part of the work zone. This could be the work place of the person for example.

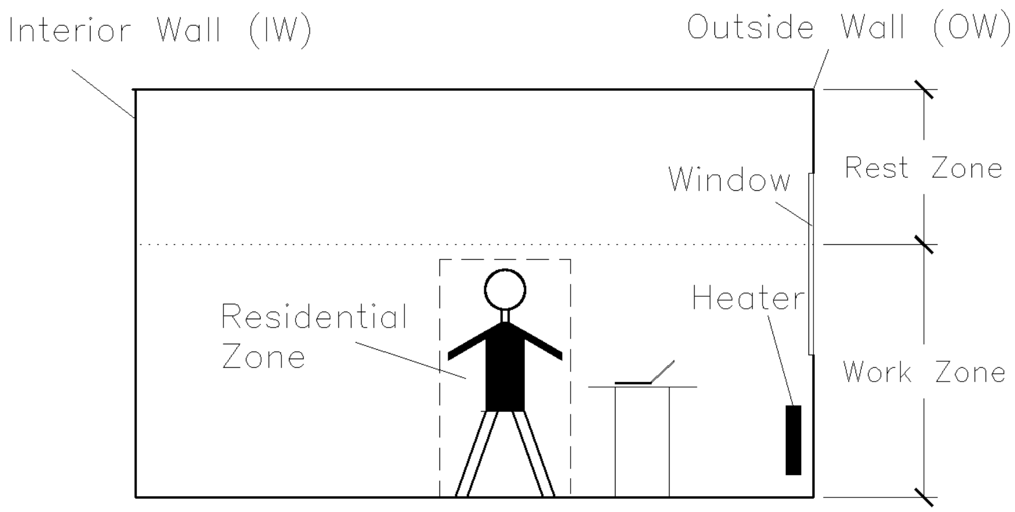


Figure 1-1 Example of a typical room

2 Hints for sensor placing

Most of modern domestic and office buildings have relatively homogeneous microclimate with minor change of the thermal comfort parameters. Rooms with big windows or heated by an oven, rooms with cooling or heating systems integrated in the walls can be the exceptions. Detailed definition of homogeneous and heterogeneous climate parameters is given in EN ISO 7726:1998 [4].

In the rooms with heterogeneous climate thermal comfort measurement should be fulfilled in the zone of person´s staying (residential zone) at the heights H1, H2, and H3. For rooms with homogeneous climate EN ISO 7726:1998 [4] recommends measurements only at the height H2. Exact values of the heights H1, H2 and H3 depend on the type of performed activity (standing or sitting activity). They are given in the Table 2-1.

Possible location for the different types of sensors will be given in the following chapters.

Table 2-1 Arrangement of the sensors during measurements of the climate parameters [4]

Locations of the sensors	**Weighting coefficients of measurements for calculation mean values**				**Recommended heights** (reference value only for guidance)	
	Homogeneous environment		Heterogeneous environment		Sitting	Standing
	Class C	Class S	Class C	Class S		
H1 Head level			1	1	1,1 m	1,7 m
H2 Abdomen level	1	1	1	2	0,6 m	1,1 m
H3 Ankle level			1	1	0,1 m	0,1 m

2.1 Temperature and humidity sensors

2.1.1 Air temperature sensors

The most precise information about air temperature can be obtained from the sensors installed at the heights H1, H2, H3 in residential zone. In rooms with homogeneous climate measurements can be fulfilled only at the height H2. A tripod can be applied for these measurements (Figure 2-1).

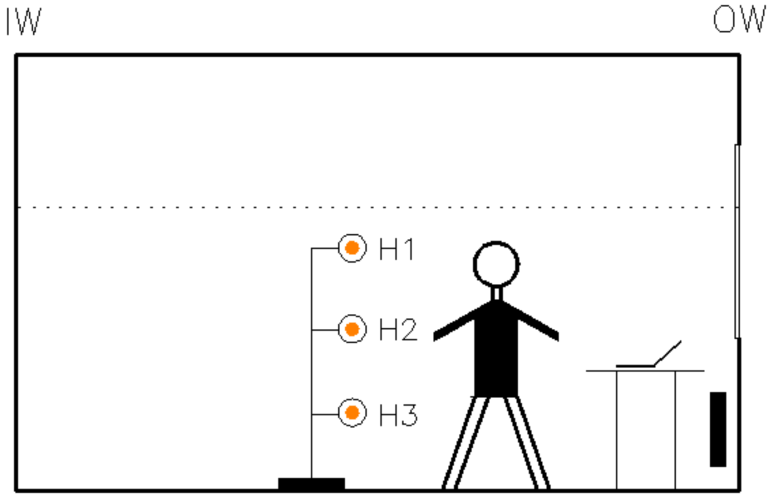


Figure 2-1 Air temperature measurement in the zone of person´s stay

- Air temperature sensor.

For a long-time monitoring it is possible to install the temperature sensor at the height H2 near indoor walls (Figure 2-2), in the case when preliminary measurements show, that the air temperature doesn`t change a lot over the room depth. It is necessary to remember that this temperature represents only general tendency of the temperature in the room.

Usually during construction position of the furniture is unknown. In that case temperature sensor can be installed on inside walls near the light switch, where it doesn´t cross with electric wiring.

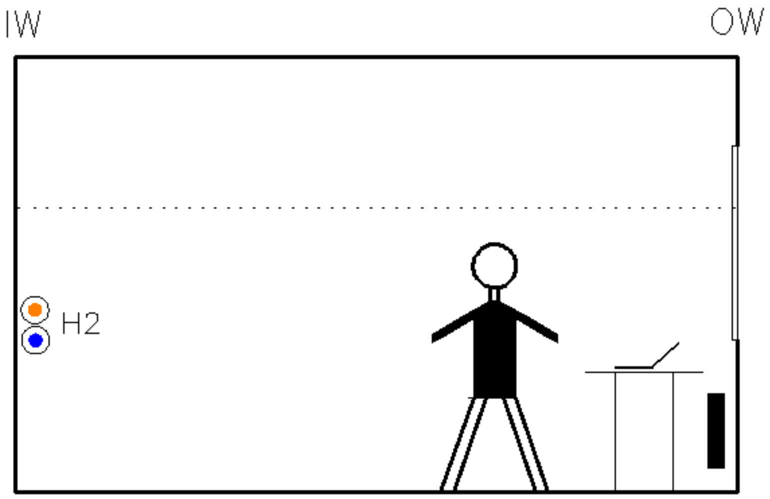


Figure 2-2 Air temperature and humidity monitoring over log time

- Air temperature sensor;
- Humidity sensor.

2.1.2 Humidity sensor

In rooms without air humidification the amount of water vapor (absolute humidity) is nearly constant across the whole room volume. That is why in most cases it is enough to place 1 humidity sensor. It could be installed at the height H2 together with the air temperature sensor (Figure 2-2).

Relative humidity rises when the air becomes colder. It can appear near cold outside walls. Using surface temperature measured by infra-red camera and absolute value of air humidity is also possible to calculate relative humidity in the air in front of the cold surface and to predict mildew formation.

2.2 Infra-red camera

Infra-red camera can be installed in the middle of the ceiling (Figure 2-3). In the rooms where ceiling is heated or cooled the infra-red camera could also be installed in the middle of the indoor wall (Figure 2-4).

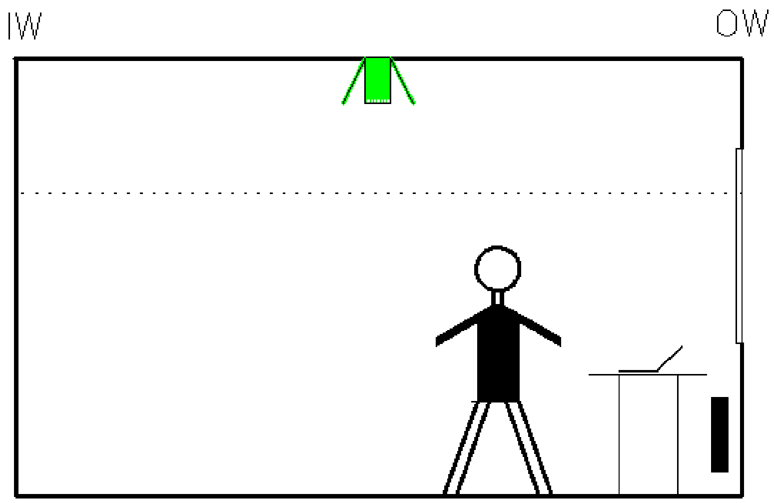
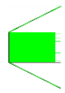


Figure 2-3 Possible position of infra-red camera

 - Infra-red camera.

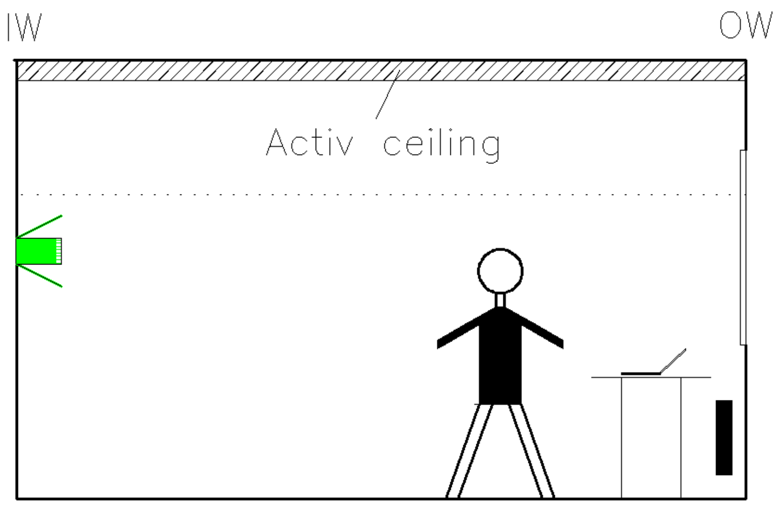


Figure 2-4 Possible position of the infra-red camera in the room with heated/cooled ceiling

2.3 Velocity sensors

According to EN ISO 7726:1998 [4] velocity sensors should be able to provide mean value and standard deviation measured during 3 minutes. Omnidirectional anemometers should be applied for the air flow measurements in rooms. It is also possible to use or a combination of 3 components which are able to measure the velocity in three perpendicularly to each other planes. For further details see [4], chapter E.3.

Installation of velocity sensors near the walls makes no sense. Because boundary layers occur near the walls, the air in front of the wall has its own velocity profile which is completely different from the air flow in the residential zone. Moreover air velocity inside the room can vary because of the leakage through exterior walls or just because of opened windows. Sources of heat/cold and supply diffusors for mechanical ventilation can also provoke significant change of the air velocity. For the most precise information about the influence of air movement on the thermal comfort velocity sensors should be placed at the heights H1, H2, H3 directly in the residential zone (Figure 2-5). Less exact will be the measurements at the height H2 in the residential zone.

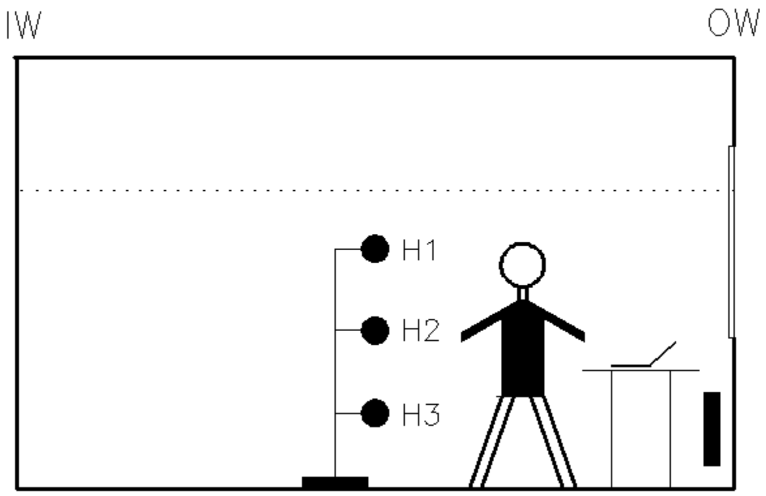


Figure 2-5 Air velocity measurement with omnidirectional anemometers in the residential zone

● - Velocity sensor.

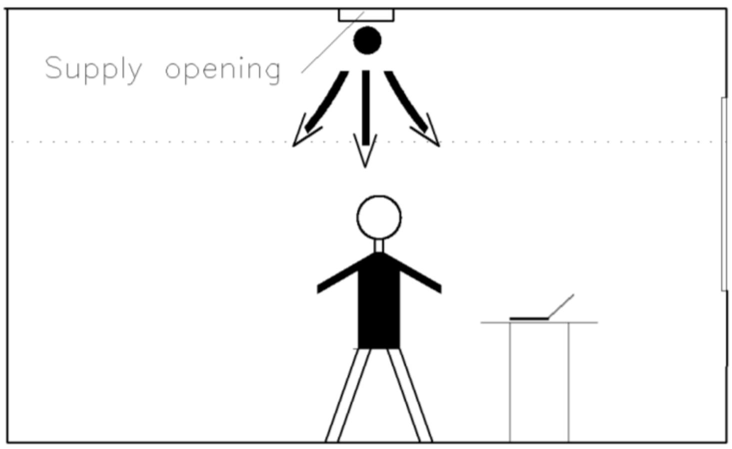


Figure 2-6 Air velocity measurement with unidirectional/bidirectional anemometers in front of the supply opening

Unidirectional (sensitive to one airflow direction) and bidirectional (sensitive to two airflow directions) anemometers can be installed in the places where the direction of the airflow can be predicted in advance. For instance directly in front the supply openings (grids, diffusors). Using this velocity at the supply (inlet) openings the average velocity in the residential zone can be calculated. For this calculation basic information provided by the producer of the inlet openings with characteristics of the openings is necessary.

Velocity sensors on the wall may be used only to measure an air stream falling from a cold window plane (Figure 2-7).

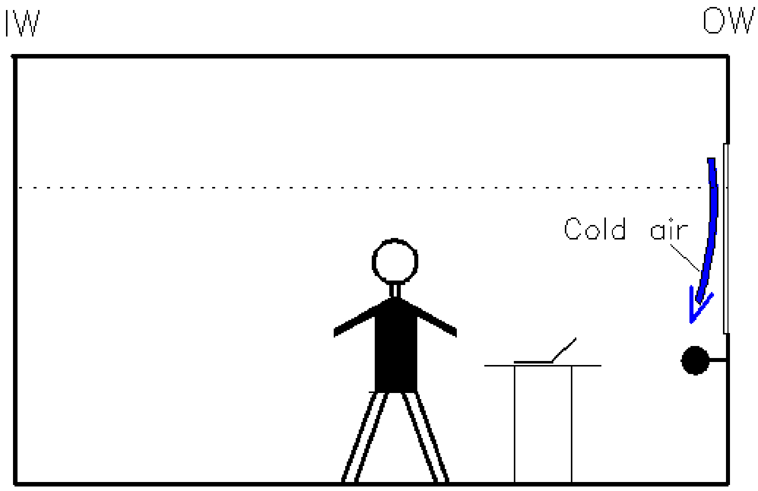


Figure 2-7 Air velocity measurement with unidirectional/bidirectional anemometers under the window

2.4 Pollutant sensors

In offices people usually have defined workplaces. The best position for the pollutant sensors is in the residential zone at the height of their "nose" (H1) (Figure 2-8). If it is impossible to place sensors in the Residential Zone (Figure 1-1) one can apply a general principle: it has no sense to measure concentration of pollutants near the places where fresh air enters the rooms, it is reasonable to install sensors in the air flow which has passed the contamination source and moves to the person, because the person breathes this air. That is why it is very important to realize how the air flows in the room (for instance with the smoke or the fog), and where can the possible contamination sources be located (by several measurement in different points in the room).

For residential buildings and for the rooms where people usually have wide activity area instead of the one workplace recommendations of EN ISO 16000-1:2006 [5] can be applied. Contamination sensors can be installed at the height 1.0 to 1.5 m in the middle of the room or in other places that are not closer than 1 m to the wall. It is advisable to divide the room in zones with similar ventilation principle and to measure concentration in each of it as simultaneously as possible. Measurements "in the sun, close to a heating system, in detected drafts or close to ventilation channels should be avoided" [5].

Time period of measurements mentioned before depends on the exposure time of contaminations, but most of the measurements are of short duration. If installation of sensors near the person for long time monitoring is impossible, they can be placed at the wall nearest to the person at the height of the head (H1) or at least within the working zone. In this case movement of contaminations through the boundary laminar sublayer to the sensor on the wall is provoked only by diffusion. Intensity of this molecular movement is significantly lower than velocity of air streams in the room. It will take time till contaminations will reach the sensor. The sensors which need air movement for their operation cannot be installed near the walls, because air velocity decreases near the walls due to the surface attrition.

It is important to remember, that measurements close to the wall give only the tendency of air contamination. Local concentrations inside the room can be obtained only due to the measurements of pollutant concentration in different points inside the room.

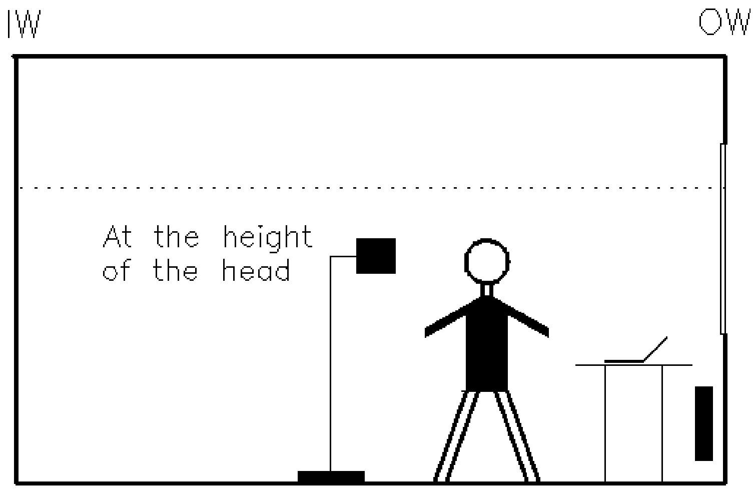


Figure 2-8 Pollutant concentration measurement in the zone of person´s stay

■ - Pollutant sensor

2.5 Illumination sensors

The positioning of the sensors depends on the application and the installed illumination system with its control features.

If one wants to regulate the color temperature and light intensity of a working surface, for instance an office desk, then the sensor is placed on the office desk itself. Installing one sensor only will lead to the regulation of just that point. In alternative, if one wants to cover a larger surface and disposes of more than one sensor, one can install a matrix of sensors (say 4 sensors on the corners of a rectangle and one the middle). To drive the illumination system however, one needs to take all the sensor values and calculate an average value.

The same reasoning is valid if one wants to achieve a given light intensity and color temperature for a person sitting on a coach in a room or for a picture/painting on a wall.

Function of the way the illumination system is built; one can also divide the room in two, three or more compartments with an RGB sensor or matrix of sensors in each compartment driving the respective systems illuminating each compartment. The risk is that the illumination systems influence each other making the control algorithm (which has to be developed in practice in function of the room, the number and position of the sensors and the illumination systems) more complex undermining the feasibility of the whole set up. This has to be tested in practice.

3 References

[1] *EN 15251:2007 Indoor environmental input parameters for design and assessment of energy performanceof buildings addressing indoor air quality, thermal environment, lighting and acoustics.*

[2] *EN ISO 7730:2005 Ergonomics of the thermal environment Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.*

[3] *EN 13779:2007 Ventilation for non-residential buildings- Performance requirements for ventilation and room-conditioning systems.*

[4] *EN ISO 7726:1998 Ergonomics of the thermal environment Instruments for measuring physical quantities.*

[5] *EN ISO 16000-1:2006 Indoor air- Part 1: General aspects of sampling strategy*.