VENTILATION AND AIR VELOCITY AT EVALUATION OF INDOOR CLIMATE

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ABSTRACT

A systematic analysis of ventilation efficiency of indoor climate in buildings is required. The article gives the strategy of that procedure and individual parameters of thermal environment and indoor air quality that must be taken into account. The discrepancies between the actual and projected values is limited. The same applied to energy use. Besides the analysis of air velocity at analyzed spot the assessment and evaluation of local air turbulence intensity is necessary as well.

1. INTRODUCTION

Poor indoor environment is widely regarded as a significant health, environment and economic problem. The systematic process of analysis of indoor air quality in buildings is imperative and it was no treated as necessary in the past. The recently new European standards (CEN, ISO) and the draft ones formed the basis for new Slovenian standards on physics of buildings named "Ventilation for buildings - General rules and design criteria for the indoor air environment in non-residental buildings". Its content was harmonized in accordance with European directives.

2. ANALYSIS OF INDOOR ENVIRONMENT

In this article as indoor environment the thermal environment and indoor air quality is meant. Indoor environment indicators should be related to a systematic process of investigation of entire building that should reflect comfort and ventilation of the building air which is measured in relation to the presence of critical sources rather than applied to entire building. Building investigation, particularly commercial and school buildings should use the structured step -wise strategy as displayed in Figure 1.

The following indicators and their critical sources could be used:

A. Comfort indicators

a. Thermal comfort criteria:

- (optimal) effective temperature
- air humidity
- mean air velocity and turbulence intensity
- radiant temperature asymmetry
- warm and cool floors
- vertical air temperature difference.

b. Occupant symptom questionnaire.

B. Ventilation indicators:
Concentration of carbon dioxide under steady-state conditions.

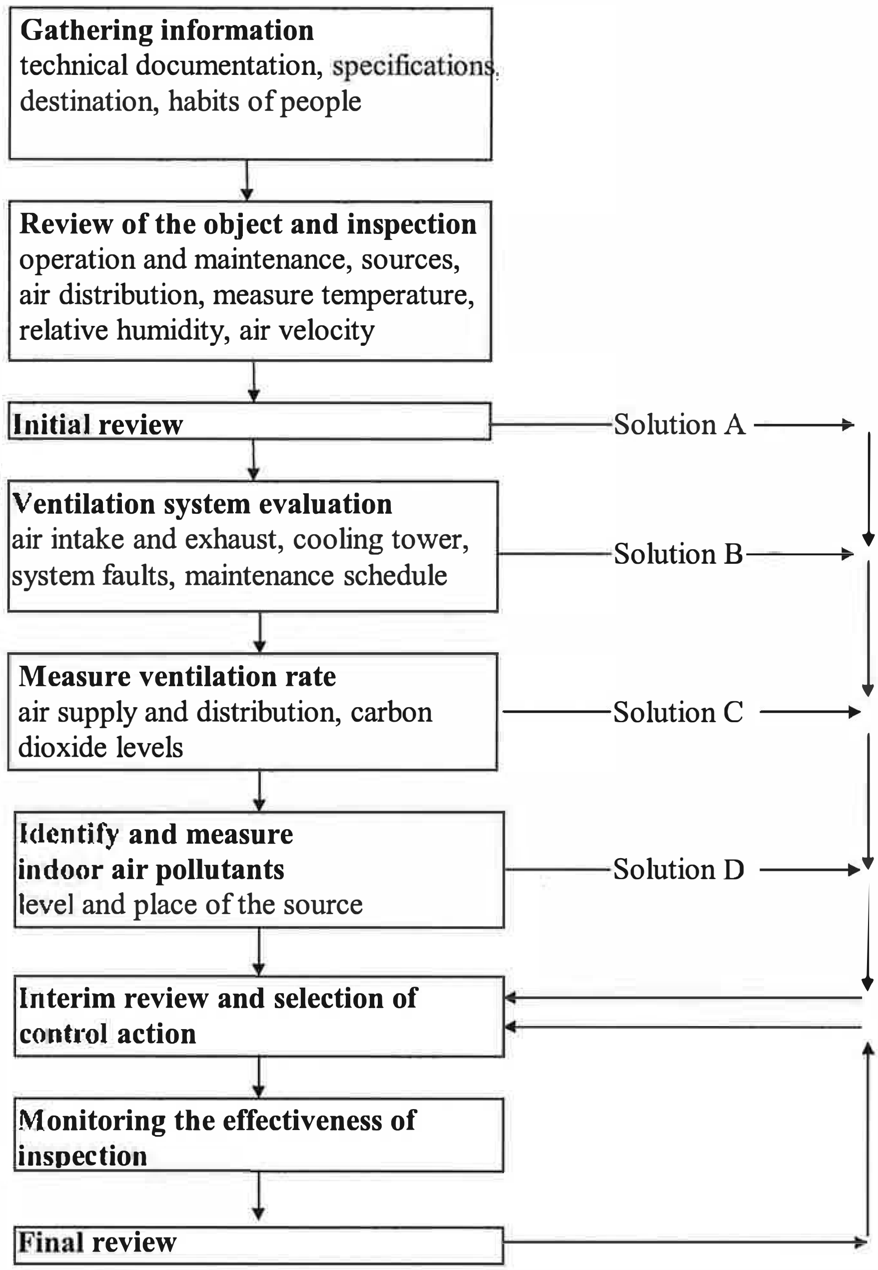

Figure 1: Strategy for investigation of indoor environment.

C. Source indicators of indoor environment:

- environmental tobacco smoke (if allowed)
- asbestos fibers
- radon
- formaldehyde
- dust mite
- volatile organic compounds,
- microbes, mustiness and fungi
- nitrogen dioxide
- carbon monoxide and dioxide
- ozone
- bacteria legionella.

3. ALLOWABLE DISCREPANCIES

The indoor climate factors and air flow rates, heating, cooling and humidifying performances and other characteristics and building ventilation design data are to be measured at nominal air flow rate as designed. Permitted variations from design values:

• Air flow rate, each individual room		± 20 %
• Air flow rate, each system		± 10 %
• Air temperatures at performance tests:	heating	± 2 °C
	cooling	± 1 °C
• Relative humidity		± 10 % abs.
• Power consumption, converted to correspond the design air flow rate		+ 15 %
• Heating and cooling performance		− 10 %
• Mean air velocity in occupied zone		+ 0,05 m/s
• Air temperature in occupied zone		± 1 °C
• Effective temperature		± 1 °C
• Sound pressure level in duct		+ 4 dB (A)
• Sound pressure level in room		+ 2 dB (A)

If the functionality of the system requires closer tolerances, these shall be specifically defined in the ventilation plan. If specific product standards call for closer tolerances, these shall be adhered to. All temperatures and heating or cooling performances shall comply with the given tolerances simultaneously. The tolerances include the permitted variations as well as any measuring error.

4. AIR VELOCITY AND TURBULENCE INTENSITY

The air velocity - draught is an unwanted local cooling of the body caused by air movement and temperature. It is the most common cause for complaint in many ventilated spaces. The feeling of body cooling depends on temperature difference between air and human skin, air velocity and air turbulence intensivity. Turbulent air flow and its increased turbulence intensity additionally causes the discomfort of human. A correlation between the percentage of dissatisfied people due to air velocity and its turbulence is given by equation 1 and shown in Figure 2.

$$PD \quad (34 - t_i).(U - 0{,}05)^{0{,}62}.(0{,}37.\overline{U}.Ti + 3{,}14) \qquad (1)$$

PD is the draught rating, i.e. percentage of people dissatisfied due to draught

t_i is the local air temperature (°C)

U is the local mean air velocity (m/s)

Ti is the local air turbulence intensity (%)

Figure 2: Three-dimensional representation of factors influencing on per-cent of dissatisfied occupants to the draught in head area.

For the purpose of analysis of influence of air movement on body, according to equation 1, besides local air temperature the mean air velocity and turbulence intensity in local spot in a space is necessary to be measured. The characteristic point in a space has three dimensions. Usually the air velocity is measured by hot wire anemometer with two or more sensors which enables measuring more components of velocity vector at particular spot of area. There are the limitations at higher turbulence intensity in a flow as in this case the sensors can not detect return air flows. Exit sensor signal depends also on momentary position air velocity vector.

Turbulent air movement is irregular condition of a spot in which case the macroscopic values of air flow show random behavior in time and space with clearly evident time-average values. Despite such random behavior the turbulent air flow is possible to asses by laws of statistics and probability.

The vector of air velocity in three dimensional Cartesian coordinate system (x, y, z) with defined velocity vector U with components (U, V, W) can be analytically assessed in dependence on its time mean value $\overline{U}$ and variance u from that value by equation 2.

$$\overline{U} \quad \frac{1}{\Delta\tau}\int_{\tau_0}^{\tau_0+\Delta\tau} U(r,\tau)d\tau \qquad (2)$$

where is

$$U \quad \overline{U}+u \qquad (3)$$

U is the momentary value, $\overline{U}$ is the time mean value and u fluctuant part of air velocity. By taking into account the others two coordinates of three-dimensional space:

$$V \quad \overline{V}+v \qquad\qquad W \quad \overline{W}+w \qquad (4)$$

the local mean air velocity can be calculated:

$$|U| \quad \sqrt{\overline{U}^2+\overline{V}^2+\overline{W}^2} \qquad (5)$$

and the turbulence intensity:

$$Ti \quad \frac{\sqrt{\frac{1}{3}(\overline{u}^2+\overline{v}^2+\overline{w}^2)}}{|U|} \qquad (6)$$

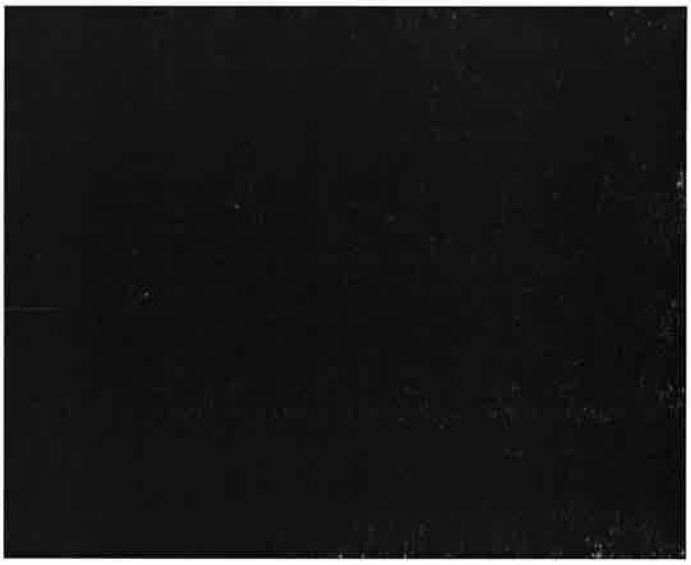

Figure 3: Air velocity in given point with different heating sistem.

The air velocities in occupied zones are usually relatively small, ranging between 0,05 - 0,3 m/s. unless there is natural or forced ventilation. Since the air velocity in a space is non-uniform fluctuation with distinctive oscillations, the measurement at a given point should be taken over a suitable period, like permanently three to five minutes, to obtain a reasonable mean value. An example of air movement in given point with evaluated mean air velocity, standard deviation and turbulence intensity for different heating systems is shown on Figure 3.

5. CONCLUSION

An appropriate thermal environment and air quality in indoor environment is necessary from the stand point of human comfort and health. The sufficient air quantity is imperative which calls for periodic analysis of indoor climate conditions.

LITERATURE

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