Indoor Environment of Buildings – Quality and Basic Ventilation Air Parameters: Part I

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Abstract— *A series of articles focused on the indoor environment of buildings. Articles discuss the importance of a quality indoor environment and the implementation of the measurement of the parameters of the outgoing air from the indoor environment in the ventilation shaft of an apartment building. The content of the first article is a description of pathogens disrupting the indoor environment, manifestations of sick building syndrome, the need for ventilation.*

Keywords— Indoor Environment, Sick Building Syndrome, Ventilation Shaft.

I. INTRODUCTION

Air is irreplaceable for breathing of all living organisms. Millions of citizens within the WHO European Region spend approximately 90% of their time indoors: in their homes (2/3 of this time), workplaces, schools, and public spaces. In recent years, the covid 19 pan-demic, high workload, and ongoing climate change have had an impact on increasing the amount of time people spend indoors to this level. And that is why the quality of this internal environment is very important, on which our health, satisfaction, well-being, but also productivity and performance depend. [1, 2]

Indoor air can be defined as air that has an indirect connection with outdoor air and is so influenced by indoor sources and activities that its quality can differ significantly from outdoor free air. [3]

II. POLLUTANTS OF THE INDOOR ENVIRONMENT

Pollutants of the indoor environment of buildings can be divided into the three following groups [3]:

- Chemical pollutants,
- Fine dust particles,
- Biological pollutants.

To identify and solve problems, pollutants can also be divided into [3, 4]:

- Pollutants, the source of which is building material and furniture, in particular: volatile organic compounds (VOC), asbestos, formaldehyde, dust particles,
- Pollutants, the source of which is human activity, in particular: VOC, CO, pesticides, tobacco smoking - ammonia, nicotine, nitrosamine, benzo-a-pyrene,
- Pollutants produced during combustion, in particular: CO, NO_2, VOC, dust particles,
- Outdoor air pollutants, in particular: CO, NO_2, VOC, dust particles, ozone,
- Pollutants arising in connection with the occurrence of moisture in buildings - moulds, mites, microorganisms, and VOC.

III. SICK BUILDING SYNDROME

A significant amount of energy is required to create thermal, light, or acoustic comfort, or to ensure high-quality, hygienically required indoor air without the presence of hazardous substances, which is used by environmental engineering systems, especially in public and residential buildings. [3]

The negative impact of various factors of the internal living environment on human health can lead to various health problems, such as allergic or infectious diseases. Triggers of these health problems are chemicals, viruses, bacteria, or moulds found in the indoor environment of buildings. These problems can be generally divided into two categories [5, 6]:

- Sick Building Syndrome (SBS),
- Building-Related Illnesses (BRI).

Manifestations of SBS are non-specific and tend to be associated with many factors, including temperature and humidity extremes in the environment. SBS is mainly manifested by itching and watery eyes, irritation and stuffy nose, throat irritation, coughing, choking, hoarseness. There is also skin irritation (allergies, itching, dry skin), hair loss, headaches, exhaustion, fatigue, reduced mental capacity, changes in sensitivity to smell, and taste, etc. [5, 6].

Confirmation of the negative health effects of the indoor environment on our health requires the use of standardized, accurate and objective methods of monitoring the relationship between the indoor microclimate (temperature, relative humidity, dustiness, air exchange, used construction materials and equipment of buildings, their external environment) and microorganisms (e.g. moulds). [5, 6].

The high occurrence of microorganisms in the indoor environment is caused both by insufficient heating of living spaces (i.e., the occurrence of temperatures below 20 °C in the indoor environment) and high relative humidity (i.e. above 50% for a long time). [7].

Regular air exchange (ventilation) plays a very important role in creating a high-quality indoor environment, especially for maintaining optimal air humidity. Ventilation, whether natural or managed (using the environmental engineering systems) is necessary for [7]:

- Fresh air supply,
- Maintaining a healthy relative humidity,
- Maintaining a low CO2 level.

IV. VENTILATION

Ventilation moves outdoor air into a building or a room and distributes the air within the building or room. The general purpose of ventilation in buildings is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it [8, 9]. During ventilation, there is no adjustment of the air properties, the adjustment of the air properties is provided by the air conditioning, for example, the adjustment of the air temperature. [10]

Building ventilation has three basic elements [11]:

- Ventilation rate — the amount of outdoor air that is provided into the space, and the quality of the outdoor air,
- Airflow direction — the overall airflow direction in a building, which should be from clean zones to dirty zones,

- Air distribution or airflow pattern — the external air should be delivered to each part of the space in an efficient manner and the airborne pollutants generated in each part of the space should also be removed in an efficient manner.

There are three methods that may be used to ventilate a building: natural, mechanical and hybrid (mixed mode) ventilation.

Areas prone to the formation of moulds are:

- Unventilated or improperly ventilated rooms (e.g., continuously cooled spaces due to the opening of ventilation holes),
- Hypothermic rooms (also in connection with saving on heating),
- Rooms with windows without micro-ventilation systems,
- Inappropriately insulated rooms (e.g., internal insulation).

This subsequently leads to a deterioration in the quality of the living space not only in terms of aesthetics (unwanted growths of fungi on interior walls, furniture, upholstery, etc.), but above all in terms of health.

Special attention should be paid to the air conditioning system, especially if it includes air humidifiers. The fact that we neglect the regular maintenance of filters, and all air conditioning systems leads to a significant increase in the concentration of germs of microorganisms in the air compared to untreated air (up to a 10,000-fold increase in the number of fungal germs in 1 m3 of air is reported). [6]

Several European standards are devoted to the ventilation of buildings, for example: EN 1886:2007 Ventilation for buildings. Air handling units. Mechanical performance; EN 12599:2012 Ventilation for buildings – Test procedures and measurement methods to hand over air conditioning and ventilation systems; EN 13053:2019 Ventilation for buildings – Air handling units – Rating and performance for units, components and sections; EN 13141 Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 1 to Part 10; CEN/TR 16798 Energy performance of buildings – Ventilation for buildings – Part 1 to Part 18.

V. ORIGINAL CONDITION OF VENTILATION IN APARTMENT BUILDINGS

Ventilation in the original construction was based on leaking windows (Fig. 1). Their normal leakage ensured the necessary and permanent exchange of air. At present, the insulation or renovation of apartment buildings is widely used. The owners are thus trying to save heating costs.

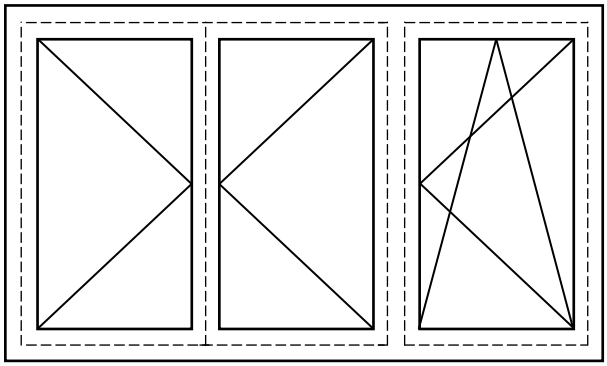

FIGURE 1: Scheme of the window with marking of ventilation gap [12]

If the building is thoroughly sealed without an alternative increase in air flow, the indoor climate will deteriorate, while the concentration of harmful substances (CO_2) and humidity will increase. There is a risk of mould formation in the living space [12].

Ventilation systems in mass housing construction were part of separately produced housing cores and installation shafts. The oldest panel houses in Slovakia have a built-in air duct in the installation shafts. Horizontal connections from the bathroom, toilet, and kitchen lead to this duct. The vent duct cap was usually installed on the outlet of the air duct on the roof of the panel house (Fig. 2).

FIGURE 2: The vent duct cap [13]

VI. METHODOLOGY FOR MEASURING THE AMOUNT AND PARAMETERS OF VENTILATION AIR

The measurement of ventilation air parameters needs to be taken comprehensively. It is important to have:

- A theoretical basis for ventilation air parameters,
- Then prepare the measurement,
- Perform the measurement itself,
- Evaluate the measurement.

VII. THEORY OF VENTILATION AIR PARAMETERS

Moist or humid air is a mixture of dry air and water vapour. The state of the air is defined by two quantities - temperature and humidity. Processes that work with moist air are mostly isobaric. This means that the corresponding pressure in the air duct differs very little from the atmospheric pressure [14, 15].

For calculations of thermal processes of moist air are applied [15]:

- Dalton's Law,
- Gas equation of state.

The relative humidity (φ or RH) is the ratio (as percentage) of the partial pressure of water vapor in air, to the vapor pressure of liquid water at the same temperature [16].

VIII. CONCLUSION

The quality of the internal environment of buildings is a topic that needs to be addressed now, especially in view of the still persistent increased risk of the spread of the Covid-19 virus and other respiratory diseases. There are also other threats to our health in connection with the prolonged exposure of humans in the internal, working or living environment of buildings. The quality of the internal environment needs to be addressed with the same importance even in view of the ongoing climate crisis. We need to deal more and more intensively with the transition from the use of fossil fuels to sustainable energy sources. And to the possibilities of how to minimize heat losses, for example by ventilation, but on the other hand, so that the internal microclimate is not affected by this. This means that it is necessary to maintain hygienic air exchange in the indoor environment. Before starting the measurement of the quality of the internal environment of the living space (more in the article Indoor Environment of Buildings – Quality and Basic Ventilation Air Parameters, Part II.) from the energy point of view, it was desirable to define this issue from a theoretical point of view, which was the content of this article.

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