

# Indoor environment quality in the museum building and its effect on heating and cooling demand



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## ABSTRACT

The paper presents the results of 1-year measurement of indoor environment parameters (temperature, relative humidity, CO<sub>2</sub> concentration) in exhibition rooms of one Polish museum in various periods of the year, and the results of simulation on thermal model of this building. The influence of a temperature control scheme in museum rooms on heating and cooling demand was analysed. The actual state (poor control of internal temperature) and ideal control of internal temperature were analysed – two cases in the winter and two cases in the summer. Simulations were performed by ESP-r program. The multi-zone model of the building was validated based on measurement data. Measurements and simulations revealed significant variations in the temperature in the rooms of the museum. The analysis showed that the maintaining internal temperature at constant level of 20 °C in winter reduces monthly heat demand in most of the exhibition rooms. Obtained effect is 5–16% depending on the premises. Provision the raise of a temperature by 1 K results in the increase of heat consumption by 6%. Maintenance of a desired internal temperature, which does not exceed 24 °C in the summer, requires the provision of coolness to the museum premises.

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## 1. Introduction

Museum is a specific object, which must meet very rigorous requirements regarding its internal microclimate. Inadequate conditions of internal environment (mainly values and fluctuations of a temperature and relative humidity) in museums can possibly deteriorate or even destroy collected exhibits. Typical collections such as wood, papers and leathers are especially sensitive to high levels of a temperature and relative humidity. UNI10829:1999 standard [1] states that ranges of optimal values of air temperature and relative humidity for ethnographic collections are 19–24 °C and 45–60% respectively, and optimum values for painting collections are 19–24 °C for temperature and 40–55% for humidity. Ranges of a temperature and humidity are also suggested in a literature. Based on different sources, van Schijndel [2] lists required ranges of a temperature and relative humidity in exhibition premises: relative humidity between 40 and 50% or between 48 and 55%, relative humidity variation less than 3% per day; air temperature between 16 and 18 °C, temperature variation less than 2 K/h. On storage conditions for paper the following values are recommended: 45–60% for relative humidity and 20 °C for mean temperature.

Other authors [3,4] recommended that fluctuations of humidity do not exceed  $\pm 5\%RH$ , and fluctuations of temperature  $\pm 3 K$  of the adopted value. Temperature and humidity fluctuations should be slow, not rapid and of short duration, because it has a devastating impact on the condition of the exhibits, especially those sensitive to changes in humidity.

There is a basic conflict between conservation and exposure of exhibits for museums. On the one hand, minimum fluctuations of room temperature and relative humidity are required. On the other hand, visitors and staff demand excellent thermal comfort and air quality [5,6]. Additionally, very often in museums in one room there are exhibits of various types, and it is difficult to choose appropriate air parameters.

Narrow range of room temperature and relative humidity should be maintained for various situations of weather and occupancy. External climate, occupants, turned on/off lighting, which are the source of excessive heat and humidity gains, have a large impact on the change of microclimate parameters in exhibition rooms and on heating and cooling demand [4,7–9].

Most of the museums are located in historic buildings, in which technical solutions often do not comply with current requirements. There are usually only central heating system and natural ventilation in these facilities, which do not provide suitable conditions for the collection and storage of the exhibits. The choice of proper, or rather the most optimal conditions for storage of museum

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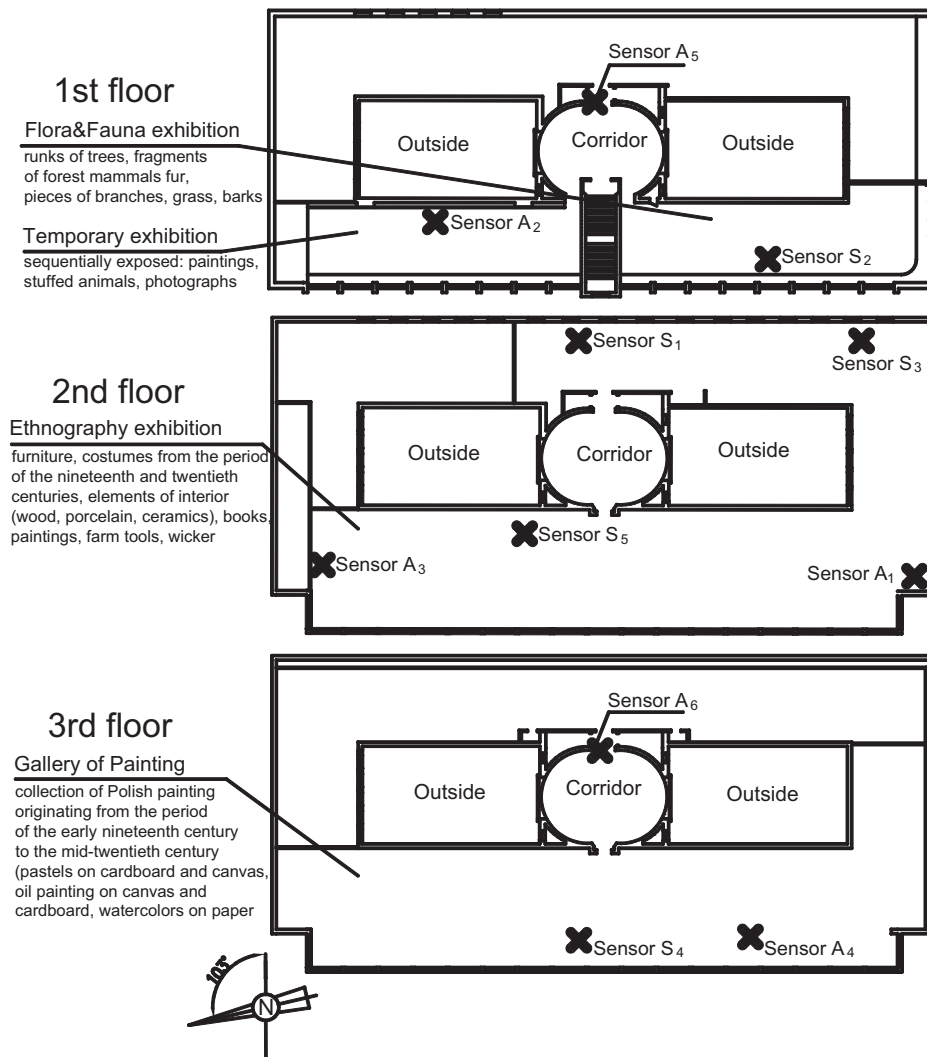


Fig. 1. Plan of the museum building with indication of the measuring points.

collections raises the question of how to maintain these parameters. The high-function HVAC systems with optimal control, working throughout the year are necessary [2,10]. This HVAC system should be well-adapted to museum requirements: a centralized air handling unit providing filtration, cooling, heating, dehumidification, humidification, maintenance and monitoring at some distance from the art collections themselves [11]. Air-conditioning system must operate constantly, so energy-saving strategies are desirable. The change of ventilation system in the room, modification of the set-point temperatures in the indoor spaces, reduction of air draught, improving window airtight, substitution of artificial lighting devices, may be simple means of energy saving in exhibition rooms [8,12–14].

The aim is to obtain homogeneous microclimate of the premises with aligned air parameters in the whole volume by appropriately selected equipment for air treatment and control devices. However, the obtainment of perfectly homogeneous air parameters in the premises by the use of a proper way of air distribution is not entirely possible [9,10,12,15,16]. Always, within a given area, certain gradient of air temperature and humidity will occur, resulting, inter alia, from mass and heat transport from the external environment to the interior of the building, or vice versa. It should also be taken into account that full air-conditioning is not always able to maintain assumed parameters of the environment, especially

in a highly variable thermal load during the day and incorrectly designed air distribution. Variable number of visitors, their concentration, unstable conditions of outdoor air, and so changeable heat and humidity gains in a short time, are often the limitation for measuring and control technique. Greater heat and humidity gains contribute to the fact that the air-conditioning installation works more intensively, and striving to achieve the balance causes fluctuations of air parameters.

Microclimate conditions in museums should be formed due to the requirements for exposed exhibits. However, due to the diversity of exposures (exhibits with different requirements exposed in one hall) and due to the maintenance of comfortable conditions for visitors, it is necessary to establish a compromise between these requirements. Often this compromise results also from limited resources for the maintenance of appropriate conditions.

The paper presents the results of actual microclimate conditions measurements, which were conducted in one of the Polish museums during the period of 1 year, from October 2009 to September 2010, under 2-year project on optimization of a microclimate in the museum premises in the case of variable outdoor and indoor loads [17] and the results of simulation on thermal model of this building. The influence of the set-point temperatures in the museum rooms on heating and cooling demand was analysed.

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