Measures That Provide the Necessary Air Parameters in Humid Rooms With a Low Temperature

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Abstract. Despite the widespread use of facilities, which include humid rooms with a low temperature, for example, underground structures of civil defense facilities, filter rooms of water intake facilities with an open water surface, underground facilities of filter rooms with main water lines, etc., the organization of the required parameters of the air regime in them is practically not studied. In the existing normative documents there are no recommendations establishing requirements to the parameters of microclimate in such rooms depending on physical and climatic influences and offering effective engineering solutions to ensure optimal conditions of air regime of premises. The unsatisfactory condition of the heat and moisture regime, the lack of recommendations for the design of heating and ventilation systems in humid areas with low temperatures of the internal air require research in the field of creating the necessary microclimate in them.

1. Introduction

The halls of filter rooms of water intake facilities belong to the premises with low temperature and high humidity. The noted conditions of their operation cause the phenomenon of moisture condensation from the air not only on the inner surfaces of enclosing constructions, but also in their thickness [6].

Meanwhile, the humidity regime determines the operational properties of the enclosing constructions of the building. It directly affects the heat-shielding properties, corrosion of metal parts, strength properties, stress-strain state, durability and aesthetics of enclosing constructions.

At high relative humidity of the internal air, more than 75%, and high humidity of the construction, the diffusion of water vapor is noticeable even at low values of the partial air pressure [7].

In humid rooms in the summer period of the year, due to the increase in temperature and relative humidity, the absolute amount of condensate formed on the inner surface of the enclosures is more significant than in the winter period.

The limiting values of air parameters in the halls of filter rooms, at which there is no condensation of water vapor on the inner surfaces of the enclosing constructions, were designed at Vladivostok's characteristic outside air temperatures during the cold and warm seasons of the year, te °C [2], temperature tint and relative humidity φint of the internal air (Fig. 1).
2. Application of natural ventilation

To maintain moisture, which excludes its condensation, it is necessary to input fresh air with insignificant humidity to the underground structure [9]. This condition cannot be fulfilled in conditions of high humidity of outdoor air in summer in the coastal regions of the south of Primorsky Krai and its supply to underground structures without changing the humidity state.

Some experts believe that in order to eliminate moisture condensation on the internal surfaces of the enclosing constructions of the filter rooms, it is enough to organize the simplest solutions for their ventilation [3, 5].

These can be considered systems with natural ventilation, however, in the specific conditions of forming the temperature and humidity conditions in humid rooms with a low temperature, the stable operation of traditional systems with a natural impulse during the year is practically impossible.

\[ Pe = 9.81 \cdot h \cdot (\rho_e - \rho_n) \ [\text{Pa}] \]  

where \( h \) - is the height of the air column [m], \( \rho_e \); \( \rho_n \) - the density of the external and internal air [kg/m³].

Consequently, the stable operation of natural exhaust ventilation is possible only if the temperature of the internal air is substantially higher than the temperature of the outside air [4].

In humid rooms with a low temperature, the functioning of natural extract ventilation is observed only in the cold period of the year, not the most problematic period for the phenomenon of moisture condensation.

In the warm period, the period of intensive separation and condensation of moisture in the halls of the filter rooms, exhaust natural ventilation functions extremely unsatisfactorily.

In view of the small value of \( Pe \) velocity of movement, the amount of transported air is very small, which significantly limits the field of application of natural ventilation systems in rooms with significant moisture emissions.

In addition, if there is only one exhaust ventilation in the room, the air to be removed must be compensated by inflow through the leakages of the vestibules of windows, doors, and in their absence,
due to the organized inflow. The absence of an organized inflow is the reason for the inefficiency of exhaust systems.

However, the inflow of untreated wet outside air during the summer period of the year, the relative humidity of which in Primorsky Krai is often 100% and the moisture content is g/kg, hampers the process of lowering the humidity in the rooms under consideration.

The above mentioned drawbacks of natural circulation systems call into question the expediency of their use as rational solutions that provide the required temperature and humidity regimes in humid rooms with a lowered temperature.

3. Ways to solve the problem

Taking into account the conditions and factors influencing the formation of the temperature and humidity regime in them, some principal decisions that can be implemented practically have been analyzed:

- combined extract and input ventilation with mechanical motivation;
- combined extract and input ventilation with industrial air dehumidifiers;
- natural ventilation with gravitational pressure amplifier.

Possibilities of organizing the necessary air parameters in the filter room are represented by the example of combined extract and input ventilation with mechanical motivation.

The outdoor air is prepared in a duct type input ventilation unit including a mixing chamber, a surface air-cooler of the input air type, an electric air heater, a ventilation aggregate. The main mode of operation of the input ventilation is a parallel flow scheme, i.e. without recycling. The presence of a mixing chamber of outdoor air and internal recirculating air allows to use partial air recirculation in a wide range of air exchanges during the cold and warm periods of the year in order to save electricity significantly for the preparation and transportation of air.

In the cold period of the year from text=13 °C to the end of the heating period recirculation mode is possible. At the same time, the external air consumption can be up to 25-30% of the total air exchange during the winter period.

The processes of changing the state of air in the room on the I-d diagram of moist air during the cold and warm periods of the year are shown in Fig. 2 and Fig. 3.

![Figure 2](image_url)

**Figure 2.** The process of changing the state of indoor air in the cold period of the year with partial air recirculation: Point 1 - parameters of outside air; Point 2 - parameters of the internal air; Point 3 - parameters of a mixture of internal and external air; Point 4 - parameters of input air entering the room.
Figure 3. The process of changing the state of air in the summer period of the year with partial air recirculation: Points 1-2 - the process of mixing the external and internal air; Point 3 - a point of a mixture. With the parameters in point 3, air enters the air cooler in the summer; Points 3-5 - the actual process of cooling and drying air in the air cooler; Points 3-4 - cooling process in an air cooler without condensation of water vapor; Points 4-5 - process of drying and cooling with condensation of water vapor; Points 5-6 - the process of heating the air in the condenser of the air dehumidifier; Points 6-1 - the process of heat consumption for evaporation of moisture at I = const.

Unlike the possibilities of natural ventilation, the combined extract and input ventilation with mechanical motivation and partial air recirculation provides round-the-clock maintenance of the necessary air parameters in rooms with a low temperature.

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