Thermal and humid microclimate

The thermal-humidity microclimate is determined by three interrelated factors – **temperature**, **relative humidity** and **air flow speed**, a change in one of the variables results in a change in the other two.

Measurement of parameters of microclimatic conditions

Some measured and determined quantities needed to evaluate the microclimatic parameters of the indoor environment:

- **Air temperature t_a (°C)**, also called dry temperature, is the temperature around the human body, measured by any temperature sensor unaffected by radiation from the surrounding surfaces.
- **The resulting temperature of the spherical thermometer t_g (°C)** is the temperature around the human body measured by the spherical thermometer, which includes the effect of the simultaneous effect of the air temperature, the temperature of the surrounding surfaces and the speed of the air flow.
- **The operative air temperature t_o (°C)** is the uniform temperature of an enclosed space within which a person would share the same heat by radiation and flow as in the real environment. It is determined by calculation.
- **The mean radiation temperature t_r (°C)** is the uniform temperature of the surrounding surfaces, at which the same heat is shared by radiation as in a real heterogeneous environment. It is measured by radiometers or calculated from the resulting temperature of a globe thermometer and air temperature. It serves as one of the input values for calculating the operative temperature.
- **Relative humidity r_h (%)** expresses the degree of air saturation with water vapor, defined by the ratio of the density of water vapor in air and in moist air saturated with water vapor at the same temperature and pressure.
- **Wet-bulb temperature t_w (°C)** ,called psychrometric, is the temperature of a forced-ventilated humidified temperature sensor used in determining the relative humidity of the air with a psychrometer.
- **The speed of air flow in v_a ($m.s^{-1}$)** is a quantity characterizing the movement of air in space, it is determined by its size and direction of flow. Since the speed of the air flow in the space fluctuates considerably, it is necessary to express its changes as an average value per unit of time.

Air temperature

It tells about thermal load or a person's subjective feeling of thermal well-being; thermal comfort is one of the factors ensuring an optimal environment for a person's stay. It can be characterized as a state of balance between the subject and the environment without straining thermoregulation system. [1]

At long-lasting **high temperatures** , symptoms of acute health disorders from heat can appear, such as nausea to vomiting, diarrhea, epistaxis and mouth bleeding, sudden and uncontrollable acceleration and deepening of breathing, a sharp decrease in sweating or diastolic blood pressure, changes in facial color, tingling and tingling, headaches, pain in the muscles, in the srdce, convulsions and often inadequate, more or less uncontrollable behavior.

When working in the **cold**, the overall effect of the cold leads to a reduction in blood flow through the skin, a rise in blood pressure and an acceleration of the heart rate, as well as an increase in oxygen consumption. The body core temperature drops, breathing weakens, heart rate slows down. A decrease in the activity of the central nervous system leads to drowsiness, with a further decrease in temperature, death occurs due to circulatory failure.

Measurement

- *Air temperature t_a*

Any temperature sensor with the required measurement accuracy of ± 0,5 °C. can be used for temperature measurement. Its thermal inertia must be taken into account (the final value can only be read after the sensor has stabilized). It is necessary to reduce the influence of ambient radiation on the temperature sensor (the measured value would then not correspond to the actual air temperature, but would lie somewhere between the air temperature and the mean radiation temperature).

- *Operative temperature t_o*
  - It is not a measured quantity, but calculated, for example, according to the relationship:
    - $t_o = t_r + A \cdot (t_a - t_r)$
      - t_a – air temperature (°C) – average value for the selected time interval
      - t_r – average radiation number (°C) – average value for the selected time interval
      - A – a coefficient that is a function of air flow speed

- *The resulting temperature of the spherical thermometer t_g*

Using a spherical thermometer - the Vernon-Jokl's spherical thermometer is used for measurement. The surface of the ball consists of black polyurethane. The stabilization time of the ball thermometer is 20-30 minutes depending on the physical properties of the ball and environmental conditions.

Humidity

In our conditions, it is customary to use relative air humidity as a humidity criterion. It is expressed as the ratio of the water vapor pressure in the air to the water vapor pressure in the saturated air, it is given in % or as a dimensionless quantity.

Indoor air humidity depends on outdoor humidity, technological or other sources, and the number of people. Recommended values are 30–70% relative humidity [1]. The optimal values for housing are 40-50%. Although humidity is much less felt by humans than temperature, the individual's condition can still be adversely affected.

During the winter, the relative humidity drops to 20% or less during heating. At that time, even in healthy individuals, there is more intense drying of the mucous membrane of the upper respiratory tract, a decrease in their protective function and an increase in the possibility of penetration of some harmful substances into the lower respiratory tract.

Excessively high relative humidity also has a negative effect - at a higher temperature and high relative humidity, the evaporation of sweat decreases and they are also ideal conditions for the growth and reproduction of mold.

Measurement

- *Psychrometry*
  - where the relative humidity value is obtained from a psychrometric table or diagram based on the measured dry temperature t_a and wet temperature t_w of a forced ventilated wet thermometer (wet stocking). Both thermometers must be protected from the effects of radiant heat.
- *Capacitive hygrometers*
  - the fluctuation of the electrical capacity of the sensor is converted to the humidity value.
- *Hygrometry*
  - i.e. hygrometers based on elongation or deformation of organic material, e.g. membrane and hair.

Air flow

Thermal comfort is also affected by the speed of air flow. A person feels every air flow, this may or may not be a source of discomfort.

Higher flow velocities usually improve thermal comfort at higher temperatures, but at the same time they can already lead to health problems. If the surface of the body cools excessively due to the rapid evaporation of sweat due to the flow of air, the body cools down (examples: excessive cooling of sweaty skin when using a table fan in the summer, air shower in facilities with heat sources).

Measurement

The speed of air flow in the space must be measured by methods that allow determining with sufficient accuracy a low flow speed of 0.05 to 0,5 $m.s^{-1}$. Because the movement of air in the space is highly turbulent and highly variable over time, it is not possible to use immediately measured values for evaluation, but only average values over a longer time interval - at least 1 min., optimally 3 min. The sensitivity of the sensor to the direction of air flow must be considered.

Hills's thermometer

- equipped with a cylindrical container filled with colored alcohol, there are 2 marks on the capillaries of the device: for 38 °C and for 35 °C. We measure the time for the filling in the capillary to drop from the upper line (38 °C) to the lower line (35 °C). We determine the air speed by calculation or subtraction from normograms.

Anemometry

- more modern anemometers are either so-called whirling anemometers, known from meteorological stations, or more accurate digital ones based on the principle of cooling the resistance spiral with flowing air.

Individual objective factors (energy expenditure and thermal resistance of clothing) also affect the resulting feeling of a person (comfort - discomfort) exposed to the aforementioned climatic factors.

Energy output

Energy expenditure (M) is expressed in gross values, which are values including basal metabolism (BM). The unit is 1 watt per 1 m^2 of the body surface of a man or woman. Energy expenditure is determined by measuring or roughly using heart rate. Methods used to assess total physical work:

- Indirect calorimetrzý – its essence is to determine the amount of energy that is released during the activity of muscles and other organs by the oxidation of nutrients. It is a very accurate method, but very demanding on

instrumentation
- Ventilometry – to determine energy expenditure by measuring lung ventilation
- Heart rate assessment – this is a comprehensive indicator of the body's load, its value can be used to estimate energy expenditure with some accuracy
- Tabular methods – the least demanding, but highly inaccurate, provide only a rough estimate of the energy intensity of the work

Thermal resistance of clothing (duty)

The thermal resistance of the clothing (clo) is calculated from the thermal balance according to the Czech technical standard on the ergonomics of the thermal environment, or based on the measurement of the body core temperature, skin temperature and heart rate Orientation methods in the field: Graphical method (number of clothing layers, air flow speed)

The effect of climatic conditions on humans

Thermal, or radiation well-being – the balance of metabolic heat flow (total heat production of a person) and the flow of heat removed from the body is maintained at optimal values of physiological parameters. The mechanical adjustment of the flow of heat from the surface of the body consists in changing the thermal resistance of the clothing and changing the activity of the person.

Assessment of climatic conditions

Subjective methods

- Well-being (0) − thermally neutral feelings of a person
- Mild discomfort (1) − a faint sensation of cold or heat
- Discomfort (2) - cold or warm, depending on the relative humidity of the air, feelings of dampness (in cold weather) or, conversely, dryness or stuffiness (in warm weather).
- Considerable discomfort (3) − cold or heat, sweating, clothing felt as completely inadequate, depending on the relative humidity of the air, feelings of dampness in winter, or significant dryness or oppressive suffocation in heat.

Objective methods

They are based on the aforementioned measurement results of the relevant physical quantities of climatic factors.

Protection of health from adverse climatic conditions

- reduction of the radiation intensity of the source – insulation, water cooling, metallic shiny surrounding surfaces
- shielding of the worker - steel screens, cooled by water
- worker cooling – air showers, direct spraying of water on the worker, cooling panels, dethermal glasses.
- thermal insulation of the worker - special clothing.

It must be said that there are considerable inter-individual differences in the perception of thermal comfort or discomfort. There are always about 5% of unsatisfied people who feel thermal discomfort − discomfort.

Links

Reference

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