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MEASURING THERMAL COMFORT IN WORKING ENVIRONMENT

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Abstract:

The working environment is very important element in the all-social contexts. A safe and healthy working environment is of great importance for the individual employee, for the enterprise and for society in general. Good working environment can mean lower absenteeism due to sickness, and this in turn affects productivity and at society level, lower absenteeism due to sickness means large financial savings.

Keywords:

Environment, physical comfort, airflow, air temperature, air humidity.

1 INTRODUCTION

Human thermal comfort depends on environmental and personal factors. The four environmental factors are airflow (wind), air temperature, air humidity, and radiation from the sun and nearby hot surfaces. The personal factors are the clothing being worn and the person's level of physical activity. Thermal sensation is also significantly affected by acclimatisation/adaptation. Physical comfort is critical to work effectiveness, satisfaction, and physical and psychological well-being. Uncomfortable conditions in the workplace - too hot, too cold, too noisy, too dark, too light, too much glare - restrict the ability of workers to function to full capacity and can lead to lowered job satisfaction and increases in illness symptoms. During the facility design and development process, building projects must have a comprehensive, integrated perspective that seeks to:

- Provide a superior acoustic environment
- Maintain optimal thermal comfort
- Create a high quality visual environment, and
- Provide furniture and equipment that will enhance worker comfort and performance.
- Provide user controls.

2 THERMO-HUMIDITY MICROCLIMATE

Microclimate is an important element of a working environment. It is needed to pay an attention especially to the thermo-humidity microclimate. By observance of rules in dependence on the type of the work it is possible to achieve optimal conditions of the working environment, which assure physiological functions of human body in connection with the working output. Periodical thermo-humidity microclimate's evaluation is necessary and useful. The evaluation methods for investigating the microclimate are based on the so-called complex system of evaluation of the microclimate, according to which the response of man, induced by the environment, is decisive, i.e. the microclimate being assessed on the basis of the thermal load on man. The methods are applied in two stages. The first stage, the so-called methods of anamnesis examination, is based on the subjective data, provided by persons, on the microclimate which they experience The second stage, the objective methods of

examination establish guidelines on where, when, what and by what methods to measure the environment under examination in relation to the type of thermal load on man.

2.1 Thermal comfort

A "thermally comfortable" environment is the ideal thermal environment for people to work in. Thermal comfort can be very subjective. Conditions that are very comfortable to one person can be uncomfortable to another. Thermal comfort is very difficult to define because you need to take into account a range of environmental and personal factors when deciding what will make people feel comfortable (Fig.1). These factors make up what is known as the 'human thermal environment'. Thermal comfort is defined in Standard ISO 7730 as: 'that condition of mind which expresses satisfaction with the thermal environment.'[3] The thermal comfort affecting six factors:

A) Environmental factors:
- Air temperature (the temperature of the air surrounding the body)
- Radiant temperature (is the heat that radiates from a warm object.)
- Air velocity (the speed of air moving across the room)
- Humidity (water in the air)

B) Personal factors:
- Clothing Insulation (insulating effect of clothing)
- Metabolic heat (body heat producing in line with physical activity.

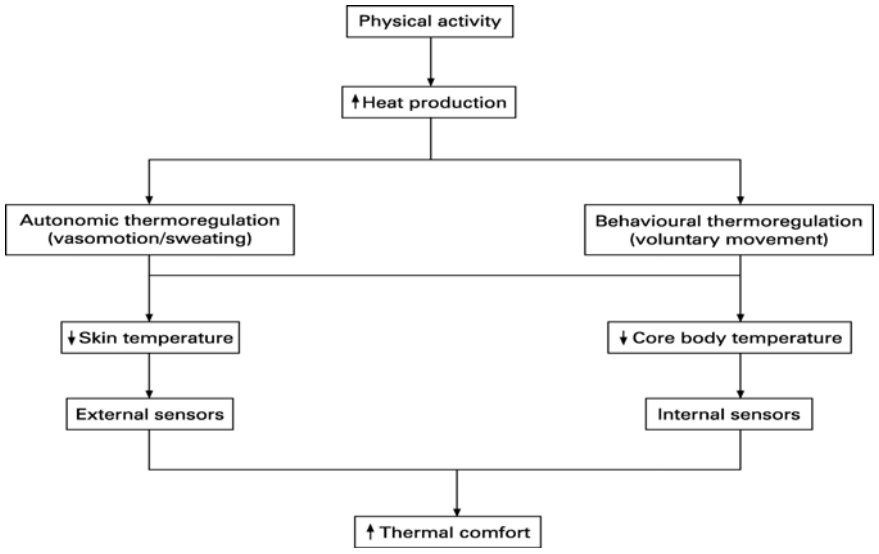

Figure 1:Tthermal comfort and physical activity

The entirety of external conditions and requirements in a working system disturbing hysiological and/or mental balance are known as work stress. hermal stress means thermal conditions in the environment causing discomfort, having a negative impact not only on thermoregulatory processes (e.g. intense sweating), but also on general feeling, physical and mental capabilities, and health [5]. This is presented in the following figure (Fig. 2).

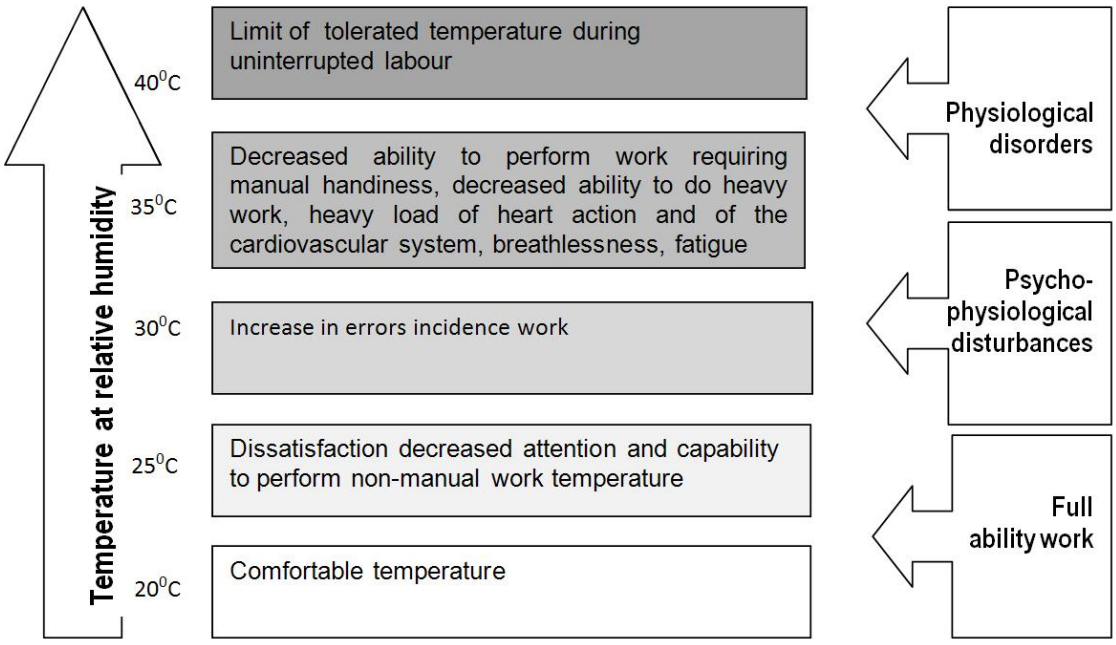

Figure 2: Impact of temperature and air relative humidity on physical and mental performance.

2.2 Evaluation and measuring

Periodical thermo-humidity microclimate's evaluation is necessary and useful. The methods of anamnesis examination are based on the subjective data, provided by persons on the microclimate, which they experience. According to ISO 7730 are setting-up index PMV - Predicted mean vote and index PPD - Percentage people dissatisfied. The PMV/PPD index predicts the thermal comfort of people working in a given environment. It becomes the most widely used index adopted as European and International standard. If the percentage of workers dissatisfied with the thermal environment is above a certain level, you will need to take action. Having considered the factors outlined above, you may need to establish a clearer picture of potential problems.

If the assessment indicates those hot or cold environments present a risk greater than just discomfort, the extent of that risk should be measured. There is range of ways to measure temperature, for example measured by a Wet Bulb Globe thermometer (WBGT) that absorbs radiant heat by a simple three-temperature element device similar on the Fig 3. The Wet Globe Temperature correlates so well with the more complicated environmental heat ratings calculated from air temperature, velocity, humidity and thermal radiation that it may be substituted for them.

The WBGT-index combines three measurements [1]:

- Natural wet-bulb temperature (Tnw)
- Globe temperature (Tg)
- Air temperature (Ta)

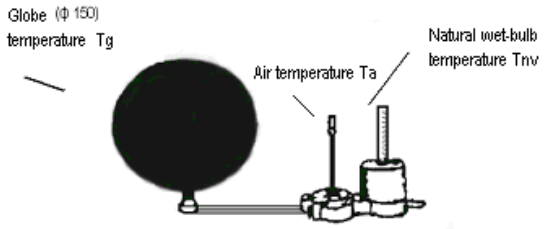

Figure 3: Three-temperature element device scheme

The three elements Tg, Tnw, and Ta are combined by into a weighted average to produce the WBGT.

$$WBGT = 0.7 \times Tnw + 0.3 \times Tg \quad (1)$$

Outside buildings with solar load, or where a radiant heat source is present indoors:

$$WBGTS = 0.7 \times Tnw + 0.2 \times Tg + 0.1 \times Ta \quad (2)$$

The measurements are entered into the above the equations to obtain a WBGT value, figure 4. The WBGT value is then compared to the reference values provided in the standard for the appropriate metabolic rate and state of acclimation of the worker. A worked example has been provided to show how the WBGT reference values may be used. They refer to conditions where 95% of the working population can be repeatedly exposed to heat stress with no adverse health effects. It is important to note that these reference values assume an employee is physically fit, in good health, normally clothed, with adequate salt and water intake and, if conditions stay within limits, are able to work effectively without exceeding a body core temperature of 38°C. Reference values of WBGT heat stress index from STN ISO 7243 related to a maximum rectal temperature of 38°C.

Figure 4: WBGT sensor, measurement, display

3 PROTECTING WORKERS IN HOT ENVIRONMENTS

The best way to reduce heat stress on workers is to minimize heat in the workplace. The following guidelines can help to reduce the heat stress and avoid the dangerous consequences:

- Stressful conditions lessening
- Minimize exposure to heat
- Rest areas
- Drinking water
- Number and duration of exposures
- Protective clothing

3.1 Stressful Conditions Lessening

Many industries have attempted to reduce the hazards of heat stress by introducing engineering controls, training workers in the recognition and prevention of heat stress, and implementing work-rest cycles. Another approach to reducing the level of heat stress is the use of engineering controls, which include ventilation and heat shielding.

3.2 Minimize Exposure to Heat

A variety of engineering controls can be introduced to minimize exposure to heat. For instance, improving the insulation on a furnace wall can reduce its surface temperature and the temperature of the area around it. In a laundry room, exhaust hoods installed over those sources releasing moisture will lower the humidity in the work area. In general, the simplest and least expensive methods of reducing heat and humidity can be accomplished by:

- Opening windows in hot work areas,
- Using fans, or
- Using other methods of creating airflow such as exhaust ventilation or air blowers.

3.3 Rest Areas

Providing cool rest areas in hot work environments considerably reduces the stress of working in those environments. There is no conclusive information available on the ideal temperature for a rest area. The rest area should be as close to the workplace as possible. Individual work periods should not be lengthened in favor of prolonged rest periods. Shorter but frequent work-rest cycles are the greatest benefit to the worker.

3.4 Drinking Water

In the course of a day's work in the heat, a worker may produce much of sweat. Because so many heat disorders involve excessive dehydration of the body, it is essential that water intake during the workday be about equal to the amount of sweat produced.

3.5 Number and Duration of Exposures

Rather than be exposed to heat for extended periods of time during the course of a job, workers should, wherever possible, be permitted to distribute the workload evenly over the day and incorporate

work-rest cycles. Work-rest cycles give the body an opportunity to get rid of excess heat, slow down the production of internal body heat, and provide greater blood flow to the skin. Workers employed outdoors are especially subject to weather changes. A hot spell or a rise in humidity can create overly stressful conditions. The following practices can help to reduce heat stress:

- Postponement of nonessential tasks
- Permit only those workers acclimatized to heat to perform the more strenuous tasks, or
- Provide additional workers to perform the task keeping in mind that all workers should have the physical capacity to perform the task and that they should be accustomed to the heat.

3.6 Protective Clothing

Clothing inhibits the transfer of heat between the body and the surrounding environment. When air temperature is higher than skin temperature, clothing helps to prevent the transfer of heat from the air to the body. In a dry work environment with very high air temperatures, the wearing of clothing could be an advantage circumstance. Certain work in hot environments may require insulated gloves, insulated suits, reflective clothing, or infrared reflecting face shields. For extremely hot conditions, thermally conditioned clothing is available. The proper type of clothing depends on the specific circumstance.

4 CONCLUSION

Heat Stress is the physiological strain caused by an increase in core body temperature. The human body maintains its core body temperature at 36,67 °(98°F) over a wide range of conditions by thermo regulatory means. The contributing factors that can affect heat stress range from metabolic heat generation, evaporation, convection, radiation and conduction. The relative humidity, air velocity and the clothing worn by the individual within that environment affect the evaporation rate. The ambient temperature affects convection and if this is higher that the body's core temperature, the body will gain additional heat. When a person is subjected to working in a hot environment the heat loss by radiation, convection and evaporation will be limited and ultimately the core body temperature will rise. This will result in greater heat stress and higher physiological strain. The microtherm WBGT instrument assists in monitoring the heat stress levels of workers thought to be at risk.

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7 SENDING THE PAPER

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