TEMPERATURE AND HUMIDITY CONDITIONS FOR PREMISES AND BUILDINGS

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Summary

Indoor climate is often defined as the collective action of all physical properties in a room affecting living organisms. This definition also includes factors such as air composition, its content such as dust, odors, microorganisms, etc., which may be of great importance for the evaluation of the indoor environment. Assessment of the latter, in particular, is considered significant due to the need for thermal comfort conditions in the room.

Apart from a discussion of the composition of indoor air and the necessity to provide thermal comfort, this chapter also deals with instruments that are usually used in order to estimate the indoor temperature and humidity.

1. Composition of Atmospheric Air

Air in its natural state (outdoors, near sea surface) is a mixture of gases, including mainly oxygen, nitrogen, argon, carbon dioxide (CO_2), hydrogen etc. The near-constant volume part of clean and dry (non-humid) air is 21% (23% mass) of oxygen and 78% (75.5% mass) of nitrogen. The actual air we breath in closed areas and in cities, even when "clean", contains water vapor and small quantities of dust, fumes, odors (organic vapor compounds) etc.

1.1 Pollution and Air Pollutants

When the concentration of air impurities rises, thus reducing air content in oxygen, air deviates further from the quality required for human beings. Such impurities are called "pollutants". The presence of pollutants in the air may be due to natural processes (decomposition of organic compounds, exhalation and excretions of living organisms) or artificial reasons (production activities, combustion products etc.). Air pollution may also be due to the presence of other constituents as gases, dust particles, microorganisms of different sizes, toxic vapors, radioactive particles, etc.

- **Air pollutants**

Carbon dioxide (CO_2) is the most known pollutant. It is being rejected by living organisms as a byproduct of biological combustion and, in large quantities, through urban and industrial combustion processes mainly for energy production.

Every human being inhales approx. $9m^3$ (11.5 kg) of air in a 24-hour period. While the air we inhale typically contains oxygen at concentrations higher than 20.5% and carbon dioxide higher than 0.03%, during exhalation, these figures become approx. 16% and 4%, respectively.

When such variations of air composition occur outdoors, the environment is not affected nor is downgraded by the odors accompanying vapors excreted by human bodies. Nevertheless, in closed areas, particularly when air renewal is carried out at a very slow rate, or when many people (smoking or hard working) have assembled in such areas, CO_2, smoke and body odors build-up and create serious inconveniences. It has been determined that a CO_2 concentration of 0.5% causes discomfort, while an oxygen concentration of as low as 12% causes serious breathing problems. The critical limit for life is 8% and, below that, asphyxiation occurs.

An increase of CO_2 content in an area may be also caused by various combustion processes. This, of course, cannot be observed under normal conditions in residences and offices. Nevertheless, a fire in a basement or in a poorly ventilated area will result in rapid reduction of oxygen and increase of carbon dioxide.

Urban and, mainly, industrial combustion processes operating on solid, liquid and gas fuels, central heating combustion applications, vehicles etc. deliver enormous quantities of CO_2 into the atmosphere, thus, significantly downgrading the quality of air in these areas. This is the reason why air in urban areas is always poorer in O_2 and richer in CO_2 compared to the air in the countryside.

Carbon monoxide (CO), which is a byproduct of incomplete combustion, is a particularly devious pollutant. For example, a gasoline engine operating for testing purposes in a basement or in a closed garage may cause a hazardous CO build-up, leading to fainting and, then, to death of all people present in the area.

Ozone (O_3), a highly toxic gas, which is also a byproduct of the internal combustion exhaust gases (Nitrogen oxides) adding to the photochemical pollution of cities, is a significant factor for downgrading the quality of urban air. Ozone is as much undesirable, on the surface of the earth, as it is desirable in the stratosphere, where it serves as a filter for the ultraviolet radiation. Ozone in our breathing vicinity, beyond a certain limit below which it behaves as a strong oxidizing medium and, consequently, as a disinfecting material, should be considered as a strong and hazardous pollutant.

Sulfur dioxide (SO_2) is a particularly destructive pollutant. It is produced during combustion of materials and, notably, of low quality liquid fuels. Concentrations varying between 0.04ppm and 2ppm (parts per million), i.e. 0.1 to 5mg/m^3 of air, are often measured. Concentrations exceeding 0.5mg/m^3 are hazardous for human beings and plants. The acidic rain, which destroys forests in industrial areas, is the result of SO_2 present in the atmosphere. SO_2 in the atmospheric air is mainly due to the combustion of thousands of tones of pitcoal in thermal power plants, central heating boiler rooms and industrial facilities.

Nitrogen-oxides (known as NOx) constitute a new hazardous air pollutant presence in the cities, which may be produced by electrical discharges but mainly through combustion at high temperatures. Combustion-produced NOx forms when nitrogen binds with oxygen either during high-temperature combustion processes, or during combustion of petroleum products containing nitrogen compounds. Nowadays, the quantity of NOx produced by combustion in central heating boilers is considered a particularly important criterion for the environmental behavior of commercially available boilers and burners.

- **Dust particles**

Dust particles constitute a very important class of pollutants. By definition, dust particles are solid particles of any shape and form, distributed in the air in various concentrations. Dusts may contain:

- Inorganic components such as sand, soot, ash, traces of metals, asbestos, cement, stone products etc.
- Organic components such as small pieces of plants, small grains, flour, hair, textile fibers (lint) etc.

The components constituting dust may be of various dimensions. Typically, dusts include particles with diameters varying between 0.0005 to 1 mm (0.5 to 1,000 μm). Among these, only those of dimensions exceeding 0.02 – 0.03 mm (20-30μm) are visible. In practice, dusts may be classified by using the terms “fine”, “medium” and “coarse”. The speed of their movement towards the ground depends upon their size and density. However, since they are of very small mass, their motion does not always conform to the direction of gravity.

The number of dust particles suspended in the air of a big city may vary (according to their size) between 50,000 up to 3,000,000 per m^3. The mass concentration of dust is significantly different in the countryside air than in the urban air and depends greatly upon the kind and the extent of industrial activity.

The majority of naturally occurring dusts disturb the breathing of human beings (and animals) but they are not considered harmful to a healthy person mainly because these humans are equipped with special filters (i.e. nasal hairs and mucosa). At relatively higher concentrations, industrial dusts, even free of any toxic materials, may be harmful because the natural protective systems of living organisms cannot fight such high concentrations.

An indirect effect of dusts in cities is that they favor the formation of fogs and prevent solar light from reaching the ground. In general, even at small concentrations, dusts cause breathing problems to allergic individuals, reduce cleanliness and cause damages to machinery (mainly, electrical and electronic).

In certain areas, dusts induce serious problems and constitute the subject for scientific studies and strict health and work regulations and prohibitions.

- **Microorganisms**

Loads of small living organisms (microorganisms) of vegetable or animal origin, germs, bacteria etc. exist in the air. They appear in a large variety of shapes (cylindrical, spherical, hair-like, spiral etc.), with lengths varying between 1 to 5μm and thicknesses between 0.5 to 1μm. Most microorganisms are multiplied rapidly through cell division. They are so widely spread in cities that densities of 1,000 up to 10,000 microorganisms per m^3 are very common. The presence of dust facilitates development and distribution of the microorganisms, because these little fellows settle on the dust and grow faster.

- **Odors**

Odors are produced by physical or chemical activities related to biological functions or activities of humans, or to fumes of substances, evaporation, combustion etc. Oil storage tanks, cesspools, kitchens, vehicles, cleaning procedures, foodstuff warehouses, flowers etc. are common sources of odors, some of which are pleasant, others tolerable and others unpleasant. The discomfort caused by odors differs greatly from one individual to another and it is significantly affected by the humidity of air and the degree of habituation of people.

1.3. **Effect of Humidity on the Temperature of Indoor Air**

Humidity (water contained in vapor form) in the indoor air is one of the basic parameters of the conditions for climatic comfort. Low humidity values cause an annoying feeling and intensify the feeling of cold because, in such conditions, the human body fluids (sweat, saliva etc) tend to evaporate. Furthermore, low humidity increases electrostatic effects (production and build-up of surface charges and particularly annoying dust accumulation) on most synthetic materials (insulators, in general). On the other hand, high humidity retards the procedure of natural cooling of skin, slowing down sweat evaporation and thus creating a feeling of a temperature higher than the actual one.

In general, desirable levels of relative humidity vary between 40% and 70%. The formation of undesirable condensates on solid surfaces in the area is particularly annoying. This occurs when the surface temperature of such solids happens to be lower than the dew point of air (e.g. window- panes in a heated area during winter). When room temperature is maintained constant, dew point rises along with the relative humidity of air. Humidity may also cause mold formation, deformation of various sensitive materials as well as deterioration of foods. In special air conditioning applications (stores selling hygroscopic products or foods without protective packing, museums, libraries, storage, and production areas), the presence of humidity may have dangerous consequences.

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Bibliography

Doebelin E. (1995). *Engineering Experimentation, Planning, Execution, Reporting.* McGraw Hill, USA. [This is a practical book giving details on planning, execution and reporting of different type of experiments].

Bechwith T.G., Marangoni R.P., Lienhard J.H. (1995). *Mechanical Measurements.* Addison-Wesley Publishing Company, USA. [The central theme of this book is the presentation of various measurement techniques].

Salisbury J.K. (1967). *Kent's Mechanical Engineers' Handbook*, Power Volume. Twelfth Edition. Wiley Handbook Series. London. UK. [This is a practical book giving details on the entire field of heat-power engineering and transportation, as well as the important aspects of fluid flow].

Fanger P.O. (1982). *Thermal Comfort, Analysis and Applications in Environmental Engineering*. Robert e. Krieger Publishing Company, Malabar, Florida, USA. [This work gives details on the PMV thermal comfort index that holds for typical winter and summer indoor conditions].

Biographical Sketch

Mrs. Irene Koronaki is an associate of the Department of Building Applications. She is a Mechanical Engineer and obtained her PhD in the Thermal Section of the Mechanical Engineering department of the National Technical University of Athens. She has experience in the field of Energy Efficiency in the building sector, regarding both building shell and services. She has participated in several research EC programmes (THERMIE, JOULE, SAVE, CRAFT) during her collaboration with the University of Athens, Department of Physics, as also as a collaborator of CRES. She is a member of ASHRAE and a registered engineer (Technical Chamber of Greece).