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The role of measurement accuracy on the thermal environment assessment by means of PMV index

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ABSTRACT

ISO 7730 Standard classifies thermal environments in three categories as a function of the PMV range value, gradually decreasing according to the need of a lower dissatisfied percentage. It is noteworthy that the PMV value is greatly affected by the changes of its independent variables (air temperature, mean radiant temperature, air velocity, relative humidity, metabolic rate and clothing insulation); therefore the accuracy requirements of sensors for the measurement of environmental quantities as well the assessment of other parameters related to the activity and clothing appear a crucial matter. This work deals with a sensitivity analysis of PMV index to the accuracy of its six independent variables. Obtained results clearly show that the widths of PMV ranges fixed for each class in 7730 are near to the PMV uncertainty related to measuring devices accuracy, making often the environment classification a random operation.

1. Introduction

In the past few years, indoor environmental quality (IEQ), which is the combined result of acoustic, visual and thermal comfort and indoor air quality, has become a frequently debated topic mainly due to its effects on the comfort, health and productivity of occupants in workplaces [1]. In particular, it has been clearly shown that thermal comfort and indoor air quality have to be considered the most relevant facets of the issue because according to Seppänen et al. [2,3], there is a clear relationship between the air temperature and the productivity in indoor environments that is shown by a decrease in performance of 2% per °C increase of temperature in the range 25–32 °C.

Thermal comfort is also strongly related to the energy saving in buildings because it is affected by both the thermo-physical characteristics of the building envelope and the HVAC system. Also, the European Energy Performance of Buildings Directive [4] for the first time has clearly stated that "… this should contribute to avoiding unnecessary use of energy and to safeguarding comfortable indoor climatic conditions (thermal comfort) in relation to the outside temperature…". To meet these needs and harmonise the calculation methodology of the energy performance of buildings, the European Committee for Standardisation (CEN) in 2007 issued the EN 15251 Standard [5] that defines "how to establish and define the main parameters to be used as input for building energy calculation and long term evaluation of the indoor environment. Finally, this standard will identify parameters to be used for monitoring and displaying of the indoor environment as recommended in the Energy Performance of Buildings Directive".

For thermal facets, EN 15251 refers to ISO 7730 Standard [6] based on the predicted mean vote (PMV) index. This sensation index is based on the ASHRAE 7-point scale (see Table 1) and the heat balance of the human body. The Predicted Percentage of Dissatisfied (PPD) is then related to the value of the PMV index.

ISO 7730 [6] introduces a classification of thermal environments based on three levels related to the values of PMV and PPD indices (see Table 2). This classification not only directly modulates the environmental thermal quality as a function of the PMV index [5,6] but also affects indoor temperature design values that have to be used as input data for the building energetic assessment in heated and mechanically cooled buildings (EN 15251 Standard [5] also makes reference to a fourth category, for $PMV < -0.7$ and $PMV > 0.7$).

According to the ISO 7730 Standard, the PMV and PPD indices depend upon six quantities: two subjective (the clothing thermal insulation and the metabolic rate) and four physical (the air temperature, the mean radiant temperature, the air velocity and the air humidity) that have to be measured or estimated to calculate the indices that lead to the thermal environment assessment. Consequently, the need of clear procedures for the measurement of the whole of involved variables appears to be a crucial step because the

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