

# **Insuring Thermal Comfort in Climatized Office Buildings**

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## **ABSTRACT**

The window coverage of buildings has increased in the past five years. This is especially true for office buildings. The national guidelines (ISO, DIN, CEN) advise designing according to the operative temperature. Following the advice leads to higher operative temperature than inside temperature in buildings with greater window coverage. We made local measurements in an office building. We determined air temperature, operative temperature, subjective thermal votes, PMV, and PPD. Our paper contains the results of these measurements and conclusions.

A new feature in our lecture is the on-spot complex thermal comfort analysis with temperature measuring, PMV-PPD measuring and a questionnaire-based survey. Measuring results have proved that a favourable temperature comfort can be assured only by taking into account the operative temperature.

## **INTRODUCTION**

Thermal comfort of people in closed place is primarily determined by the radiation and convective thermal interchange with the environment. Radiation thermal interchange with the environment depends on the size of radiating surfaces and on surface temperature. Therefore subjective thermal vote is substantially influenced by the window coverage of buildings. From the aspect of subjective thermal vote operative air temperature is more important than dry air temperature as the previous one includes radiation temperature of walls and the neighbouring surfaces. Subjective thermal votes can be assessed in a complex way on the basis of PMV and PPD values in view the clothing and activity level of people.

In course of our on-spot measurements we have carried out the following studies of thermal comfort in an office building with window coverage of 45%

- measurement of air humidity content
- measurement of PMV and PPD features
- a questionnaire-based survey of subjective thermal vote, by using a five-grade scale

## **METHODS**

The purpose of our on-spot measuring and of the questionnaire-based study is as follows:

- objective measurement and analysis of thermal comfort on the basis of air temperature and PMV-PPD,
- subjective assessment of thermal comfort on the basis of a five-grade scale
- evaluation of air temperature and PMV features
- comparison of the subjective questionnaire and the measured PPD features, assessment

Subjective thermal vote analysis was carried out on the 3rd floor of the five-storied bank office building.

Date of the measurements: 17 January 1996 -9. February 1996

The field study has been performed by means physical measurements combined with psychological test, questioners. The place was an central building of a bank (the Size 45x65 m and 9 levels, appr. 70000 m<sup>3</sup>). The number of the observed rooms were 14 (20-170 m<sup>2</sup> ground).

Number of employees on the floor under survey: 84

The questionnaire on subjective thermal votes has been filled in by: 57 persons

During the field measurements the temperature of the outdoor air was between -1.5 and -2 °C.

For PMV and PPD measurements we used Thermal Comfort Meter (Type 1212) and THERM 2246 and TESTO 610 type thermometers. Our measuring test was based on normal office work carried out under normal operating conditions, in normal clothing.

- level of activity: 1 Met

- clothing:  $I_{clo} = 1,0$  ( suits, dresses typical to business people)  
 $I_{clo} = 0,8$  ( business suit without coat)

Measuring points were placed at typical workstations of the offices.

Categories of evaluation we used for the questionnaire on subjective thermal votes.

- cold
- cool
- pleasant
- slightly warm
- warm

## **RESULTS**

On the basis of on-spot measurements and the evaluation of questionnaires we had the following results:

### 1. Measurement of the condition of air

| <b>Air temperature</b> |         | <b>Humidity content</b> |
|------------------------|---------|-------------------------|
| average                | 23,1 °C | 53,9%                   |
| standard deviation     | 0,77 °C | 2,4%                    |
| maximum                | 24,7°C  | 58,0%                   |
| minimum                | 21,8 °C | 48,0%                   |
| number of measurements | 32      | 32                      |

### 2. PMV and PPD measuring results

Analysis of the measurement results is shown in PMV and PPD histograms. (Figures 1-2)

### 3. Questionnaire-based Subjective thermal vote evaluation

The results of the questionnaire based survey are shown in Figure 3, in a five-grade subjective thermal vote scale.

### CONCLUSION

1. Regarding the internal parameters of micro climate the offices are appropriate and up to the relevant Hungarian Standard (MSZ) in respect of subjective thermal vote.

2. PMV data clearly reflect a subjective thermal vote of cold. Sensation of cold is increasing in case of  $I_{clo} = 0.8$ . PPD diagrams clearly shows a high ratio of dissatisfied people. In respect of subjective thermal votes the workstation under survey are inappropriate. Based on PMV measurements the thermal effect of window coverage (surfaces) can be compensated with an air temperature increase of  $\sim 1,5$  °C .

Results of the questionnaire survey show that 21% of the interviewed had a feeling of warm whereas 47% of them had a feeling of cold The small extent of warm sensation is due to 66% participation of the employees, whereas in PMV measuring most of the measuring points were typical workstations near the windows.

The results of the study prove -among others - that operative temperature should be used as the basis of designing and operation rather than air temperature. In case a larger window coverage is applied the thermal comfort can be provided for by an increased air temperature or by radiation heat gain.

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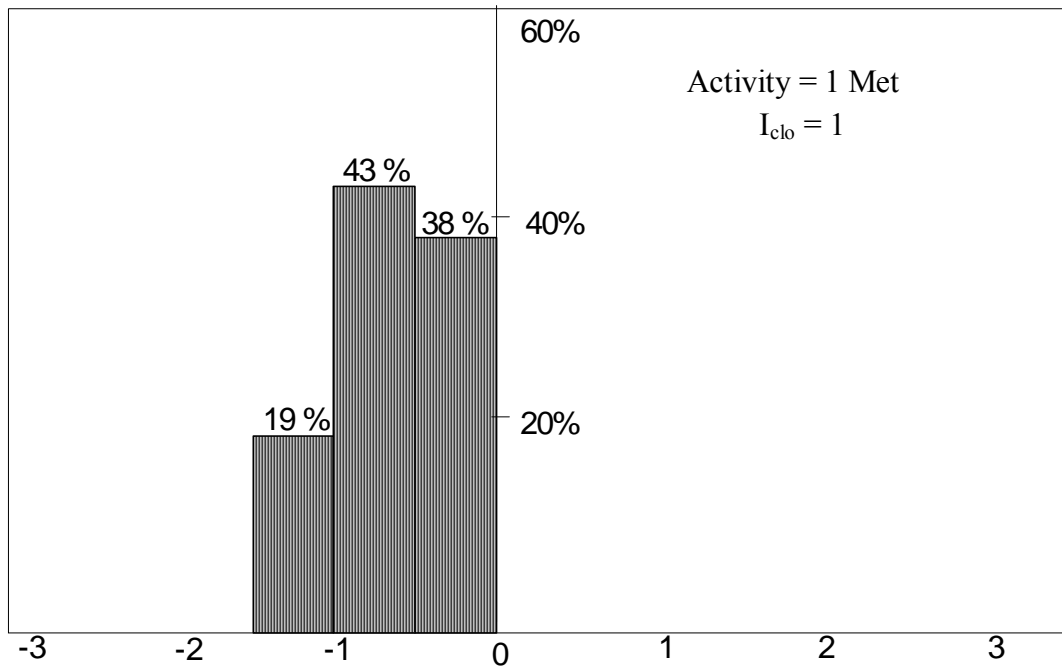
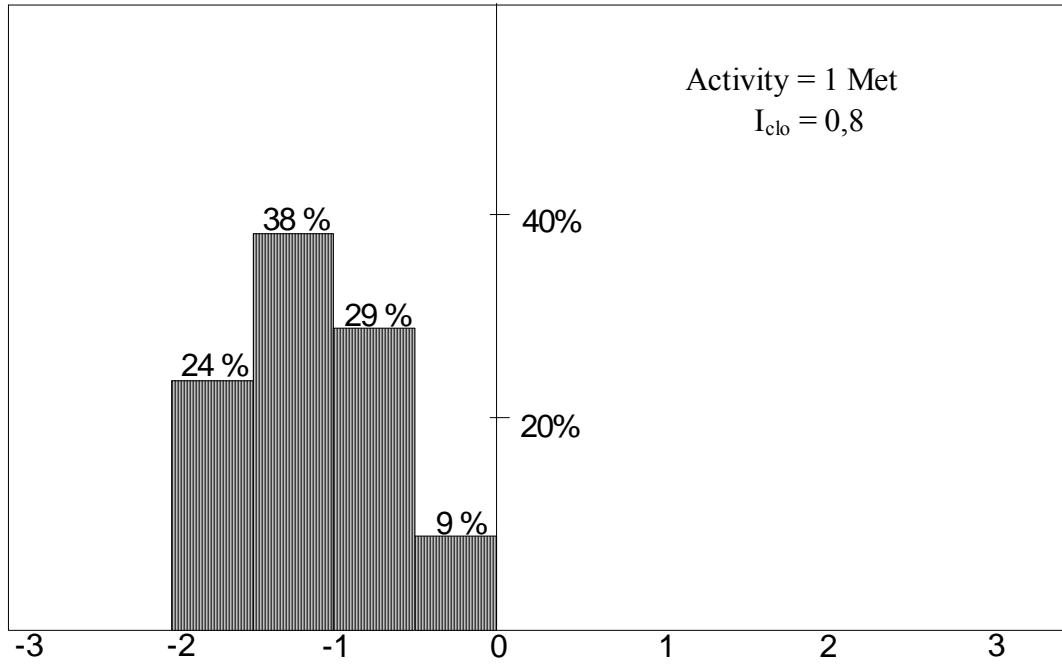
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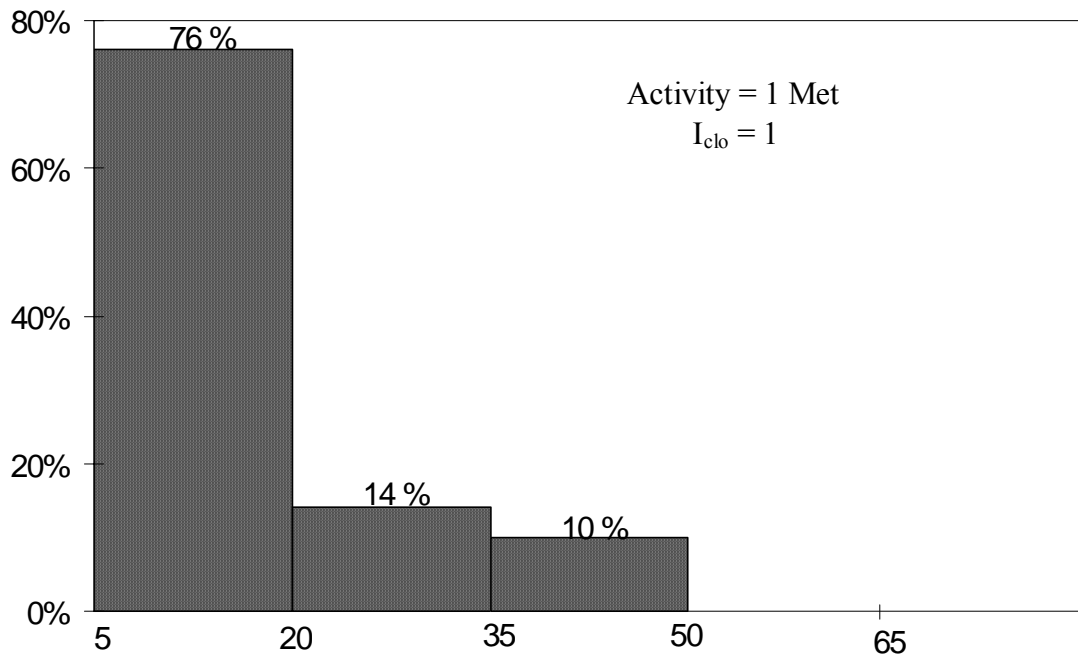
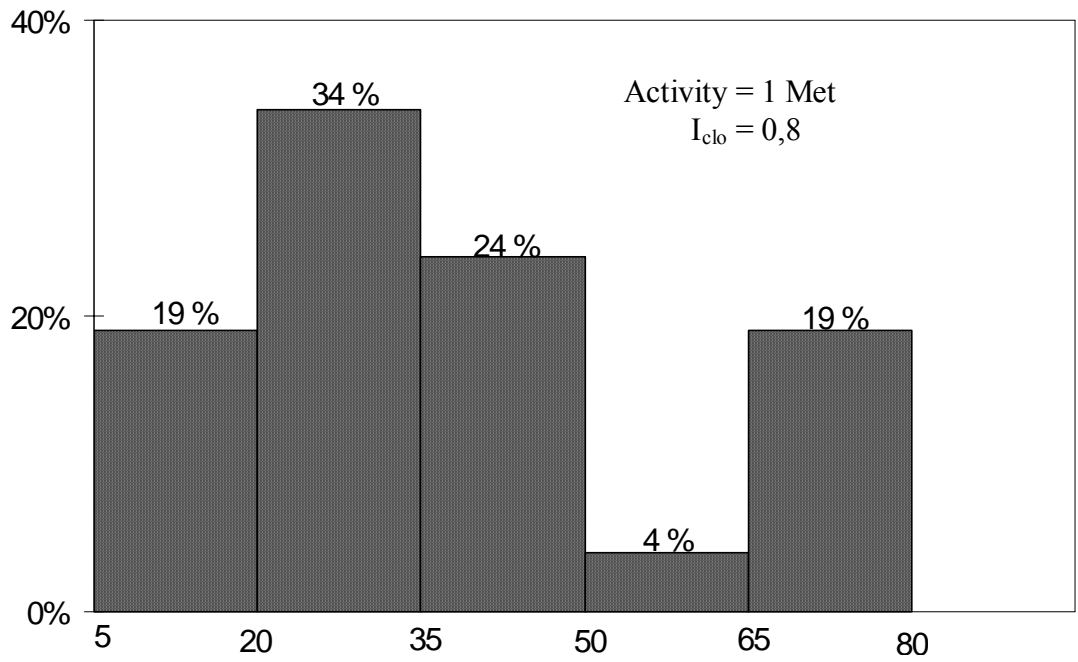
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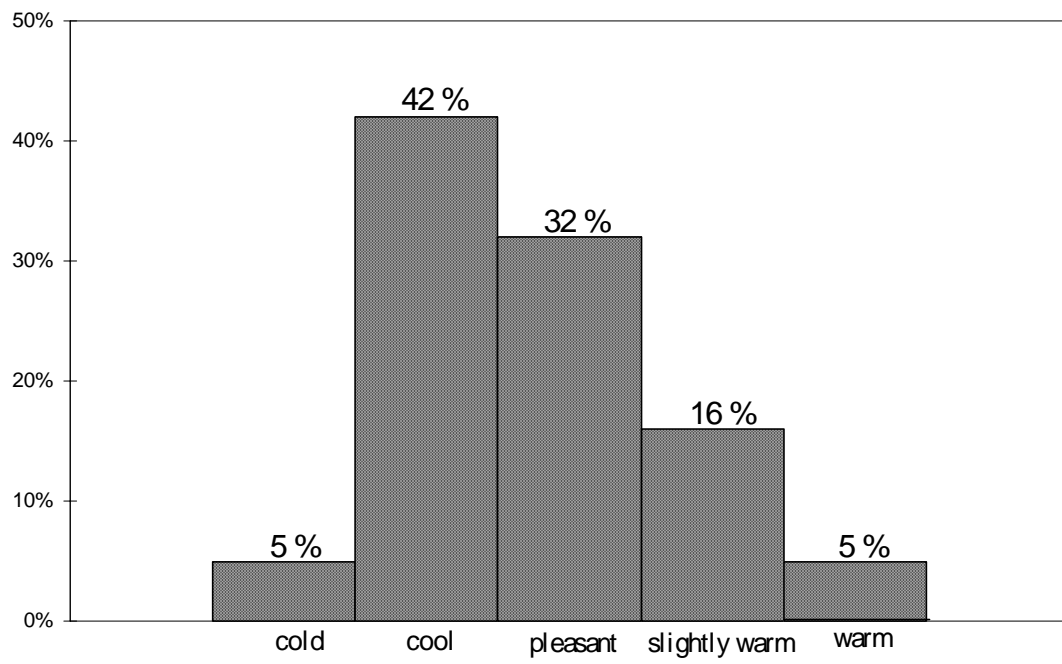
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**Fig. 1.** Histogram of PMV results



**Fig. 2.** Histogram of PPD results



**Fig. 3.** Results of questionnaire-based thermal vote evaluation