



Office Indoor Climate Analysis

Stockholms Stadsbibliotek

December 2009

Professor Dr.-Ing. Peter Marx

Berlin, Germany

Contents

- 1. Introduction**
- 2. Climate Analysis**
- 3. Test Objects**
- 4. Analysis method**
- 5. Results of the measurement**
- 6. Summary**

Annexes

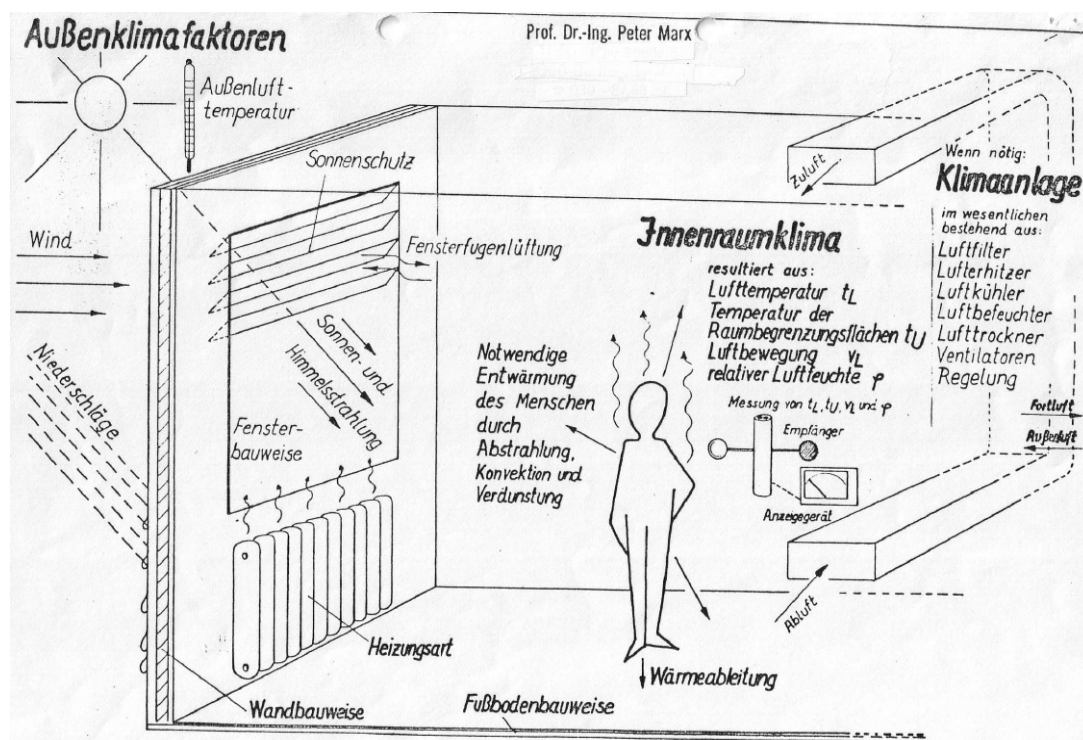
- I. Nomogram & Test Protocols**
- II. Raumklima Analysator**
- III. Results from Climate Analysis Deutsche Welle**

1. Introduction

On behalf of Stockholms Stad (City of Stockholm), through the Swedish company ThermoGaia AB, I was engaged to perform a Climate Analysis at Stockholm Main Library. The analysis was made to understand how two different rooms are influenced depending on the coating by using an independent measurement method. The test was performed in the 5th and 6th of December 2009.

2. Climate Analysis

The purpose with Climate Analysis measurement is to identify and measure the different factors that are influencing the human body according to comfort climate levels in a room.



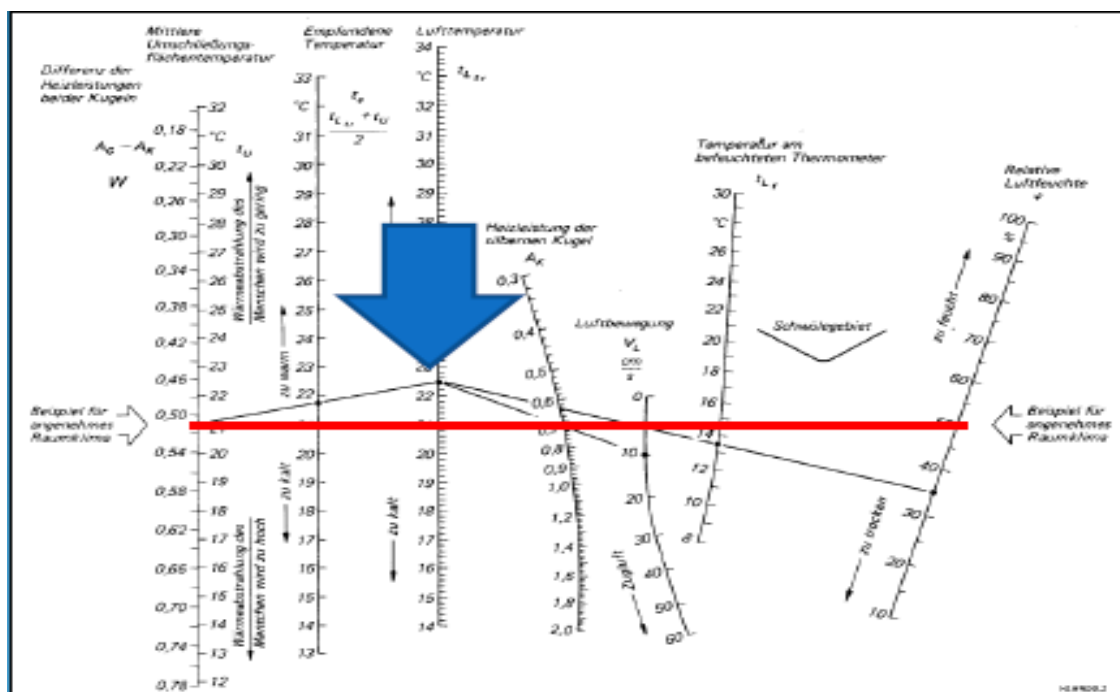
The perceived indoor climate depends on a combination of several different factors. In order to measure the “thermische Behaglichkeit” (thermal comfort) the following factors have been defined and can be measured:

- wet air temperature
- dry air temperature
- relative humidity
- infrared radiation temperature (average temperature of the room enveloping areas)

- air movement
- perceived temperature (an objective physical value which is the combination of all above measurements and not a subjective value)

The nomogram shown below is a way of describing the different parameters and to illustrate how they are related to each other. This method is recognized and has been used since 1980 to measure room climate conditions in a more scientific and accurate way.

This method can also be used in how to show differences between ThermoShield and traditional painted rooms.



The red line is the ideal comfort indoor climate for a human body.

3. Test Objects

The test object that has been chosen was two similar rooms in the upper floor in the southeast part of the library. The rooms were used for traditional office work. The rooms were equally large with each an area of 17,4 square meters. The furniture was as similar as possible in a normal office environment. The rooms contained the same type of radiators and they were located in the same part of the building next to one another.

- **Room 615** had been coated with ThermoShield Interior on the 17:th of October on both the ceiling and all its walls. Orange color in diagrams.
- **Room 613** was painted with traditional paint. Blue color.



Room 613



Room 615

4. Climate Analysis Method

Equipment

- A measure equipment for climate analysis
- A table in the middle of the room to place the apparatus and its power supply.
- An electric heater: i.e. 2 kW during a heating time of 0,5 h = 1 kWh energy input.
- A stop watch and/or a timer switch.



Measurement device



Sensor device

What to measure

- wet air temperature
- dry air temperature
- relative humidity
- infrared radiation temperature (average temperature of the room enveloping areas)
- air movement
- perceived temperature (an objective physical value which is the combination of all above measurements and not a subjective value)

Presentation of the results

The objective is to measure the heating up performance, the climate behavior after opening a window, the behavior of the room when adding humidity. The report will contain information on the method, the filled out nomograms as well as a short evaluation of the results.

Measurement Program

Close both rooms the day before and secure the same level on the radiators.

Day 1

- M1** – comparison of start room climates as start values is needed.
- M2** – changes after opening the window. Open the window for exactly 15 minutes. Measure the changed values in both rooms.
- M3** – changes after Heat up with heat fan, same time and same performance. I.e. $2 \text{ kW} \times 0,5 \text{ h} = 1 \text{ kWh}$ Measure the changed values in both rooms.
- M4** – measure the temperature after 160 minutes. Measure the changed values in both rooms.

Close the thermostats of the radiators. Open the doors to the corridor to start day 2 with the same temperature in the two rooms.

Day 2

- M5** – comparison of start room climates as a start value is needed. Measure the given values.
- M6** – repeat the heating up test in the rooms. Heat up with heat fan, same time and same performance. I.e. $2 \text{ kW} \times 0,5 \text{ h} = 1 \text{ kWh}$. Measure the changed values in both rooms.
- M7** - influence of humidity. Use a device that creates water damp (i.e. “steam duck”, same amount in both rooms 400 ml. Measure the changed values in both rooms.
- M8** – wait 15 minutes and repeat the measurement procedure. Measure the changed values in both rooms.
- M9** – open the window for exactly 10 minutes. Measure the changed values in both rooms.

5. Results of the measurement

Definitions

t_u – infrared radiation temperature

t_e – perceived temperature

$t_{L\ tr}$ – dry air temperature

$t_{L\ f}$ – wet air temperature

ϕ – relative humidity

V_L – convection

M1 - comparison of start room temperature in the measurement showed that the room coated with ThermoShield was 1,4 °C warmer than the painted room.

M2 - the cooling down process when opening the window shows that a faster cooling process in the ThermoShield coated room has a larger difference than in the painted room.

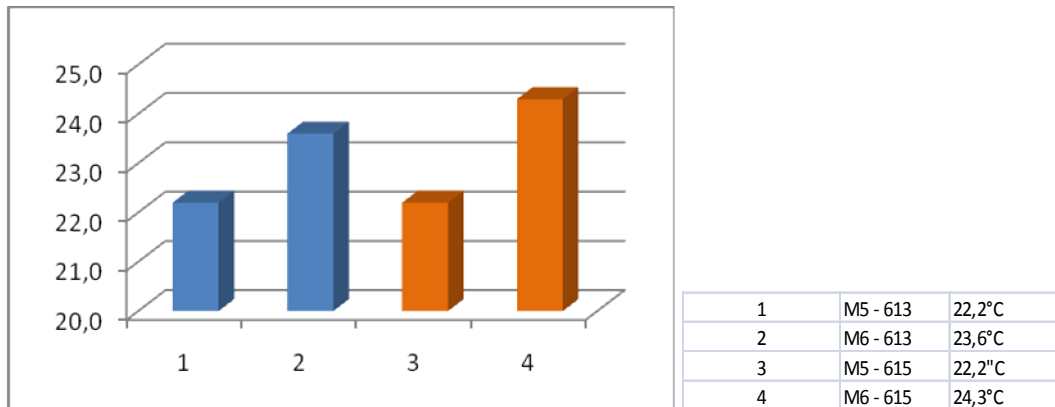
M3 – Heating up process is faster in 615 than in 613.

M5 - The perceived temperature was almost the same in booth rooms and the relative air humidity was 1 percent dryer in room 615. Good starting point for comparisons.

M6 – M6, the air humidity has been reduced from 34,5 to 29 % and the radiation temperature is the same in room 613. In room 615 the humidity had decreased from 33,5 to 31,0 and the radiation temperature have increased from 23,2 to 24,5 degrees.

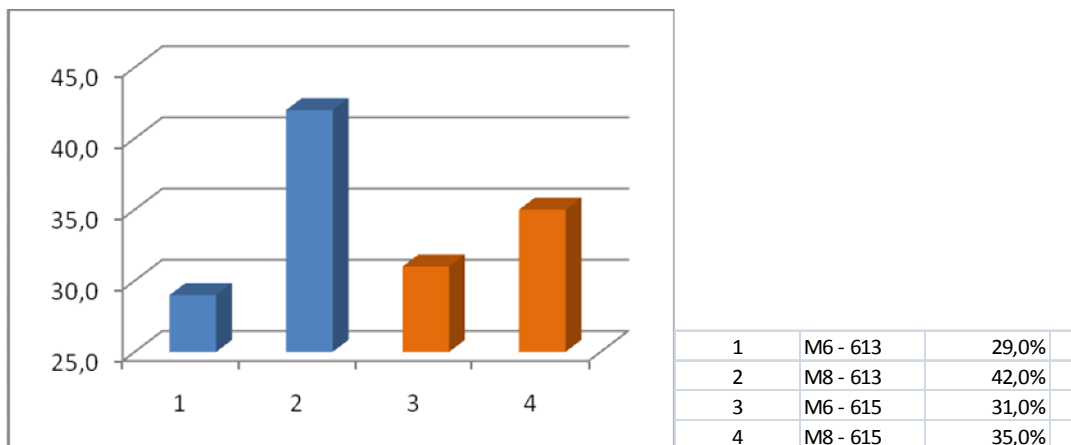
Temperature increase is 50 % higher in room 615 compared to room 613.

M6 After Heat up with heat fan 1 kWh



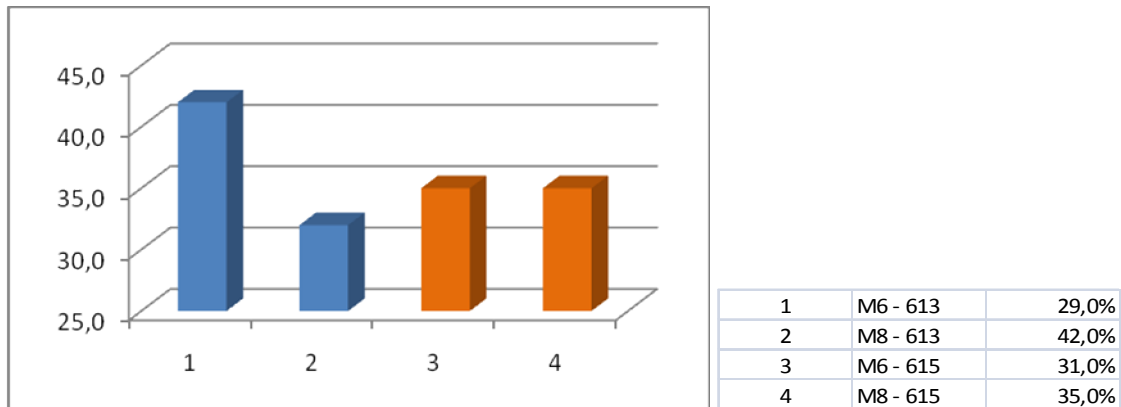
Change of t_e after heating with 1 kW/h effect input.

M8 - After 400 ml of water steamed into both rooms. The humidity level changes less in room 615 in comparison to room 613.



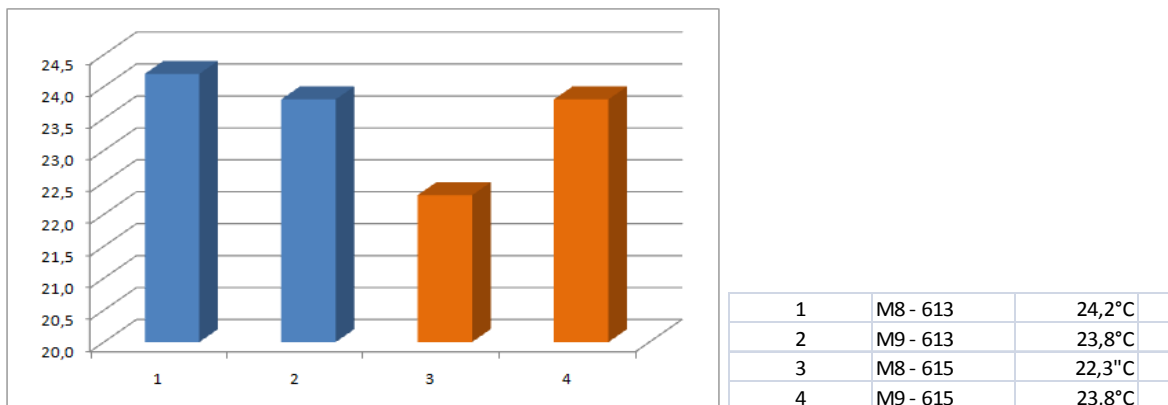
Change of air humidity after 400 ml of steamed water

M9 – When opening the window the humidity in room 615 stays the same and the humidity in room 613 decreases from 42% to 32%



Change of air humidity after opening the window

M9 – t_u in room 613 decreases slightly after opening the window but in room 615 t_u is increasing.



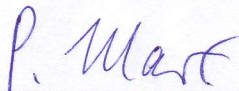
Change of t_u after opening the window

6. Summary

Conclusions are as follows:

- Day one
 - Room 615 was 9,1% warmer than room 613. In order to gain the same temperature both room were cooled.
 - The cooling down process when opening the window shows a faster cooling process in the room 615 and has a larger difference than in room 613.
- Day two
 - Temperature increase is 50 % higher in room 615 compared to room 613.
 - When adding humidity to the rooms and measuring the relative humidity in the rooms. The measurement M6, M8 and M9 shows less humidity changing in room 615 as in room 613.
- Overall
 - Both rooms are too warm and too dry. This is also applicable for the main library environment.

Berlin, 13th of January 2010



.....
Professor Dr. – Ing. Peter Marx