

ADDITIONAL CONTROL OF AMBIENT CONDITIONS IN MASS METROLOGY AND ITS INFLUENCE ON MEASUREMENT QUALITY

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1. Abstract

Mass determination by use of mass comparators is influenced by different parameters including the conditions of ambient air. Having a look at the temperature of weights and the gravitational field gradients, the relatively small impact of these parameters on mass determination can be easily determined on the base of reproducible measurement results. Of metrological interest is the air density determination and control during a measurement series that could be used to improve the quality of measurement. The influence of temperature change as a function of time and its control simultaneously during the weighting process is discussed. The implementation and use of small climate chambers around the mass comparators to smooth out the temperature and relative moisture variations is described and discussed.

2. Introduction

Determined and controlled environmental conditions (temperature and moisture) are necessary in laboratory measurements of mass and density. The measurement conditions are determined by the international rules and should be completely fulfilled. For calibration of high accuracy weights the temperature, relative humidity and horizontal and vertical gradients are defined by the international recommendation. The temperature change during the calibration may be within $\pm 0.5\text{K}/1\text{h}$, while relative humidity should be within 40-55% with maximal rate of change of $\pm 5\%/4\text{h}$. Horizontal and vertical temperature gradient changes are limited to maximum of $0.1\text{K}/\text{m}$ and $0.2\text{K}/\text{m}$, respectively.

To assure that these requirements are met special climate-chambers were constructed and build with geometry suited to the particular comparator type. The handling and adjusting of the comparator were not to be compromised or limited by the construction of the chamber. The chambers were tested in real conditions and exhibited satisfactory performances.

3. Ambient conditions in mass metrology and the use of climate chambers

The impact of ambient conditions in mass metrology is considerable. In practical calibration work parameters for which correction formulas can be established are only air density, the temperature of the weights and the gravitation field gradient. The air density in general varies and must be determined simultaneously with the event through its parameters: pressure, temperature and relative humidity. Through the control of ambient conditions the impact of these parameters should be kept as small as possible. In case of having constant ambient conditions, the weighing system drift should be constant and standard deviation of measurement becomes smaller.



Figure 1: Laboratory for mass

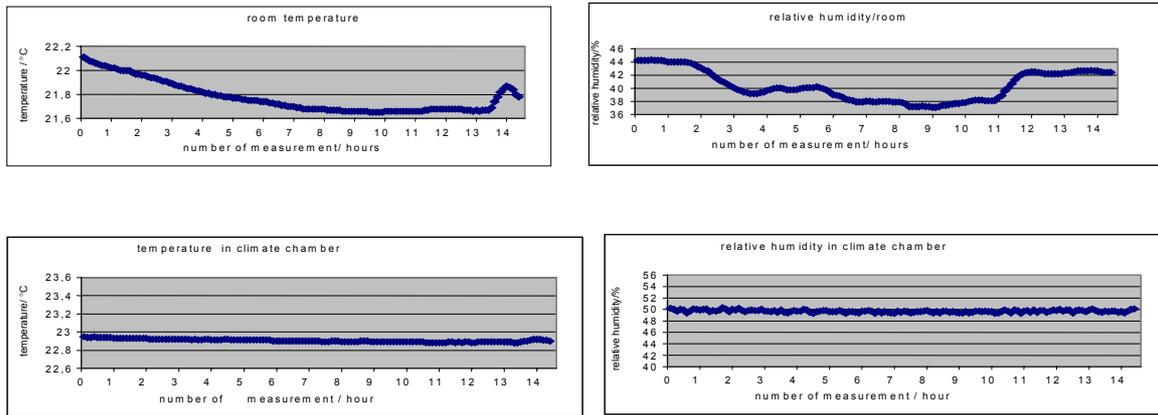


Figure 2: Data for temperature and relative humidity in laboratory and climate chamber

4. Description of the chamber

The chamber's walls are made from insulating-glass material and the connecting and supporting structure is from aluminum to ensure nonmagnetic properties. Within the chamber space there are no moving parts or mechanism, so that the all possible vibration sources are eliminated. Necessary aggregates are separated from the chamber, insulated vibrationally and connected with the chamber via flexible tubing that does not convey vibrations. Heat source mass is very small, hence source inertia is negligible. Humidity generator operates on principle that water vapor is produced from the hydrosol in laminar flow. This ensures precise control of water vapor quantity introduced into the chamber. This technical solution ensures extremely small humidity-temperature dependence. The flow in the chamber is uniform without local turbulences and in velocity range 5-10 cm/s (permitted value is 20 cm/s). All vital chamber functions are controlled by the PID program, whose parameters could be changed at will in order to optimize the conditions. The accuracy of measurement and control devices is in 0.1% class.

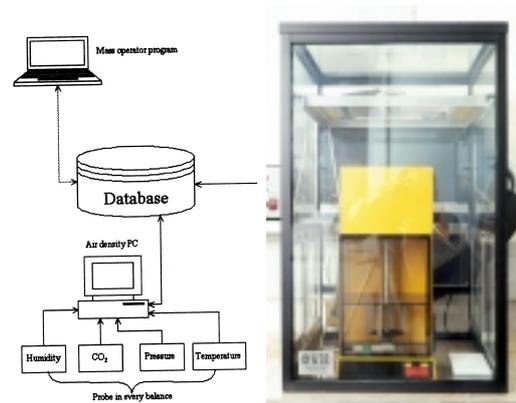


Figure 3: Climate chamber of 10-50 g mass comparator

5. Performance

Performance of the chamber was monitored and recorded during the 6 month period. The target requirements were met as shown by achieved performances:

- Temperature stability: $\pm 0.15\text{K}$ - time unlimited
- stability of the relative humidity: $\pm 1\%$ - time unlimited
- vertical temperature gradient: $< 0.2\text{K/m}$
- horizontal temperature gradient: $< 0.1\text{K/m}$
- range of temperature regulation: $\leq 1\text{K}$ from ambient temperature
- range of relative humidity regulation: $\leq 3\%$ from ambient r.h. (operational upper r.h. limit 80%).

6. References:

- M.Glaser: "Advices for the calibration of mass standards" PTB-MA-52. Braunschweig, January 1997
- 2. OIML R 111 International recommendation Part:1