DISSEMINATION OF THE MASS UNIT WITH VACUUM MASS COMPARISONS

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Abstract: Laboratory of primary mass metrology continue work on dissemination of mass unit using measurements under non ambient conditions using vacuum mass comparator. Method presented in this paper allows determination of mass and volume of weights in range 100 g – 1 kg with separate mass and volume standards.

Keywords: Mass calibration, volume calibration, dissemination of mass unit.

1. INTRODUCTION

Most important task of the laboratory of primary mass metrology is maintenance and dissemination of the mass unit. The national mass standard of Czech Republic is represented by platinum-iridium prototype which is calibrated every 10 years at BIPM.

Calibration of the primary weight set is done by subdivision method using stainless steel standards directly traceable to national prototype. The volumes of the weights have to be known prior the measurement. Also the air density has to be known for air buoyancy correction.

With air buoyancy artefacts the air density can be measured directly at the time of calibration but this method is limited to nominal masses of 1 kg only. Method presented by authors overcomes this limitation with special set of equations.

2. DISSEMINATION OF THE UNIT OF MASS

Using special air buoyancy artefacts we can calibrate mass of the weight without knowledge of the volume according to the equation

$$m_T = m_R + \frac{\Delta I_1(\Delta U_2 - \Delta U_0) - \Delta I_2(\Delta U_1 - \Delta U_0)}{\Delta U_2 - \Delta U_1}. \qquad (1)$$

The volume of the weights can be calibrated at the same time with volume standard according to equation

$$V_T = V_R + \frac{\Delta I_2 - \Delta I_1}{\Delta U_2 - \Delta U_1} \Delta V. \qquad (2)$$

ΔI is difference of indications between test and reference weight, ΔU is also difference of indications but of air buoyancy artefacts. We need two different environments of different densities (such as ambient air and vacuum) marked as *1* and *2*. Difference of indications in vacuum ΔU_0 between air buoyancy artefacts has to be known as well together with their volume difference.

Because of the limitations of the buoyancy artefacts we have to use different system of equations for the subdivision method. Proposed plan of measurements shows the plan for calibration of 4 pieces of weights with nominal masses 500 g. The plan can be used for both mass and volume calibration.

$$A = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 1 & -1 & -1 & 1 \end{pmatrix} \qquad (3)$$

Similar system of equations will be developed for the whole range 100 g – 1 kg.

3. EQUIPMENT

All measurements will be performed on vacuum mass comparator Mettler Toledo M-One with six positions for weights. Two of them will be used for air density determination, other two for mass and volume standard and the rest for different combinations of test weights.

The test weights used for this experiment are of cylindrical shape. One of the 1 kg stainless steel weights will be used as the mass reference, the silicon sphere will be used as volume reference.

The surface sorption artefacts are not yet used in this pilot measurement however it is expected that the mass change caused by sorption is 0,2 μg/cm² for stainless steel weights. The value was determined during EMRP project.

4. CONCLUSIONS

The method proposed by authors shows that it is possible to perform dissemination of the mass unit and calibration of the volume of the weights at the same time under any combination of environments of different densities.

Dissemination of the mass unit under vacuum conditions together with calibration of volume will provide means for calibration of weights after redefinition of the kilogram

where institute using vacuum mass comparator will be able to use standards stored under vacuum or pure gas conditions.

5. REFERENCES

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