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HYDROSTATIC WEIGHING APPARATUS FOR THE DENSITY DETERMINATION OF LARGE WEIGHTS

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Abstract: This paper presents a hydrostatic weighing apparatus(HWA) for the density determination of weights in the range of 2 kg to 10 kg including 1 kg. The measurement is based on Archimedes' principle by using 1 kg sphere as a solid density standard to determine the density of the reference liquid. The HWA consists of a precision balance, a immersion pan, reference weights, a weight carrier, a sample carrier, a reference liquid, a thermostat, and a controller for stepping motors. The reference weights with capacity of 1 kg, 2 kg, 2 kg, 5, kg, and 10 kg are designed and installed to be weighed at the bottom of balance. The measurement uncertainty of density of weights are evaluated as preliminary test of newly designed and fabricated equipment.

Keywords: Hydrostatic weighing, Density of weight, Reference liquid, Reference weight.

1. INTRODUCTION

A HWA has been utilized as a device in order to determine the best accuracy of weight density. As of today KRISS has just measured the density of weights by using HWA in the range of 1 g to 1 kg, and have been developing new HWA to determine the density of weights with shape of OIML 111 in the range of 2 kg to 10 kg including 1 kg.[1][2][3] The HWA is to weigh accurate buoyancy of weights in reference liquid by using 1 kg Zerodur sphere as a solid density standard to measure the density of the reference liquid. The main parts of HWA comprises a precision balance, a immersion pan, carriers for reference weights and sample weights, a thermostat for reference liquid, and a controller for stepping motors. The measurement uncertainty of density of weights are evaluated as preliminary test of newly designed and fabricated equipment

2. EQUIPMENT

The schematic drawing of new HWA is shown as figure 1. This device is fabricated to determine the density of 2 kg to 10 kg weights including 1 kg with the shape of OIML IR 111. The HWA comprises a precision balance, a immersion pan, reference weights, a weight carrier, a sample carrier, a reference liquid, a thermostat, and a controller for stepping motors. The balance has a capacity of 28 kg with a readability of 1 mg. The reference weights of 1 kg, 2 kg, 2 kg, 5 kg, and 10 kg are designed as a slotted shape and installed to be weighed at the bottom of balance. The reference weights can be combined and weighed by five stepping motors to measure reciprocal sensitivity of the balance scale. The three immersion pans with material of titanium are designed for sample weights of 1 kg to 2 kg, 5 kg, and 10 kg, respectively, and each pan is also designed to allow 1 kg sphere as a solid density standard to be weighed. The sample carrier with three stages is designed to weigh samples 1 kg to 2 kg, and 5 kg to 10 kg including 1 kg sphere by two stepping motors which can make rotation and up-and-down motion. The controller is designed to control five reference weights by stepping motors and rotation and load-unload of samples by two stepping motors, and is available by computer.

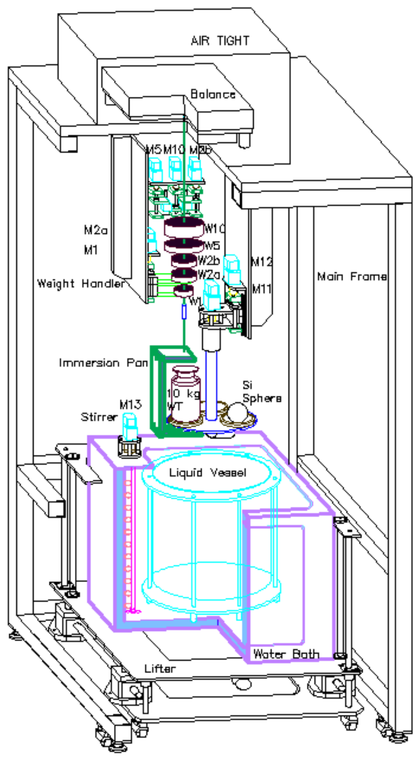

Figure 1. Schematic drawing of hydrostatic weighing apparatus in the range of 1 kg to 10 kg

3. PRELIMINARY EXAMINATIONS

The density of weights are measured for testing preliminary performance of developing HWA by manual. As reference liquid, pure water is used, whose density is measured by 1 kg Zerodur sphere.

As shown in figure 2, the density of the pure water measured as the uncertainty of about 1×10^{-4} gcm^{-3} at the confidence level of about 95 % by this HWA corresponded with the reference density table of water presented in Metrologia.

In this study, this uncertainty of pure water is far bigger than that of about 5×10^{-6} gcm^{-3} in precise hydrostatic weighing apparatus with 0.01 mg of 1 kg balance readability. The elements of this big uncertainty due to water(FMB in Figure2) could be estimated as surface tension by irregular meniscus for suspension wire and bubbles on the sphere. Therefore, reference liquid is going to be exchanged by tridecane with low surface tension.

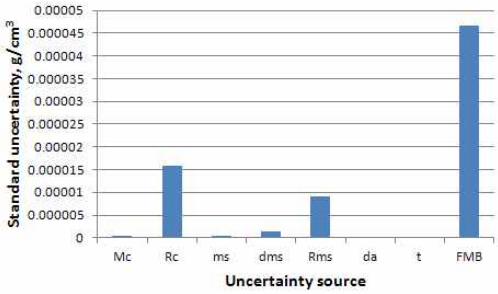

Figure 2. Standard uncertainty of reference liquid

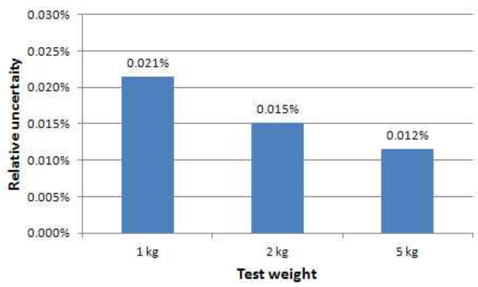

Figure 3. Relative uncertainty of sample weights

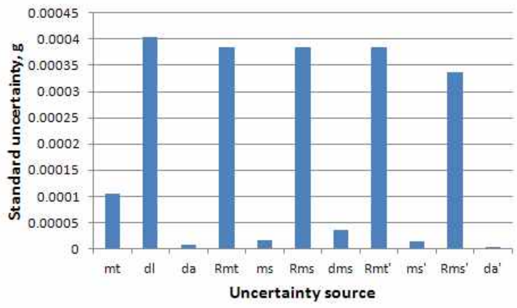

Figure 4. Standard uncertainty of 1 kg weight

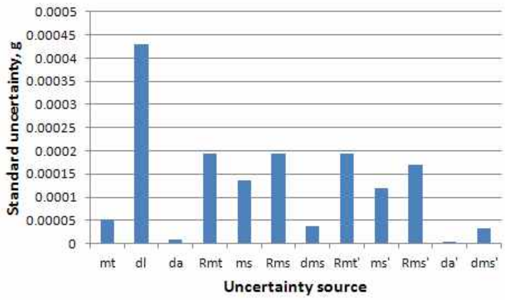

Figure 5. Standard uncertainty of 2 kg weight

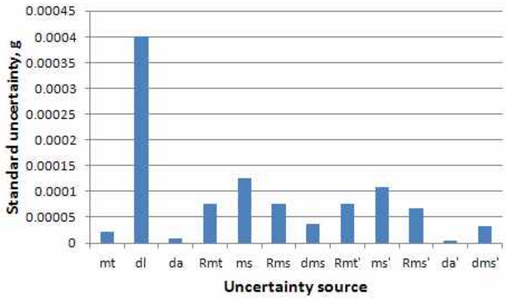

Figure 6. Standard uncertainty of 5 kg weight

The density measurement results of sample weights for 1 kg, 2 kg, 5 kg are shown in figure 3 with (8.0061±0.017, 0.021 %), (8.0135±0.012, 0.015 %), and (8.0000±0.0009, 0.012 %) in gcm^{-3}, respectively.

Figure 4,5, and 6 show the standard uncertainties for 1 kg, 2 kg, 5 kg, respectively. We also found that the biggest source of the standard uncertainties is the density of reference liquid (dl in figures)

4. CONCLUSIONS

A novel hydrostatic weighing apparatus has been being developed to determine the density of weights for 1 kg to 10 kg with shape of OIML 111. As of now, 10 kg weight has not been measured due to not preparation of its immersion pan. To improve present uncertainty for weights, reference liquid is going to change pure water as major source of uncertainty into tridecane and all operation of this device will also be automated by computer.

5. REFERENCES

References

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