Volume Determination for 2 kg~20 kg in NIM

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ABSTRACT

In NIM, it has already set up the volume determination system from 20 kg to 1 g. But regarding the weights from 2 kg to 20 kg, it is taken method A3 in OIML R111 to measure the volume of weights. Comparing the other two methods mentioned in OIML R111 and the volume comparator VC1005 at mass lab in NIM, the measuring accuracy couldn't meet the requirements of national secondary standard weight set.

A new volume measuring system is being set up at mass lab in NIM, to replace the old mechanical system. There are two working positions not only in the liquid but in the air as well. The weighing method to determine the volume of weights from 2 kg to 20 kg is taken method A1 mentioned in OIML R111.

Key words: volume of weight, volume comparison, solid density, measurement

1. INTRODUCTION

In the mass standard laboratory of NIM, the equipments for determining density of weights have been set up over twenty-five years. At that moment, the density of liquid (three-distilled water) was used as the primary standard to determine the density of weights. The mechanical balances were the main parts for measuring the volume of weights. There were WIEN 50 (made by Austria, maximum capacity is 20 kg, readability in liquid is 40 mg), TG 11 (made by Shanghai, China, maximum capacity is 1 kg, readability in liquid is 0.5 mg), and WIEN 200 (made by Austria, maximum capacity is 200 g, readability in liquid is 0.1 mg). By these equipments, the volume of weights from 20 kg to 20 g could be determined and used for air buoyancy correction when carrying out the mass dissemination.

At the end of last century, as the development of science and technology, volume comparator was imported by Would Bank Loan at NIM in 1998 to replace two mechanical balances, whose capacities are less than 1 kg. The main part of volume comparator is an electrical balance, AT1005. Its maximum capacity is 1 kg and readability is 0.01 mg. Since then, the measuring range of density of weights was enlarged from 1 kg down to 1 g rather than 20 g. By this equipment, all of the density measurements could be traceable to the solid density not only the density of weights but the liquid in the bath as well, except the weights from 2 kg to 20 kg.

Comparing with the volume comparator VC1005, the accuracy of WIEN 50/20 kg is significant lower and couldn't meet the requirements for the high accurate mass measurement. In order to increase the

precision and traceability of density determination for large masses from 2 kg to 20 kg, a new volume measuring system should be developed urgently. Based on the principle of method A1 in OIML R111 and the construction of VC1005, this volume measuring system has been developed in NIM since 2011. Because the weighing method is comparison, it is called volume comparator as well. The main part of the comparator is an electrical balance XP26003L. Its maximum capacity is 26 kg and readability is 1 mg. We hope the volume of weights from 2 kg up to 20 kg could be measured and traceable to the solid density as well by this new system.

2. MECHANICAL EQUIPMENT

This volume system was set up at the mass standard laboratory in NIM in 1970's and a mechanical balance used to measure the volume of weights is imported from Austria, see Fig1. By measuring the buoyancy difference between the tested weight in air and in liquid, the volume of weight could be determined by this system. So the density of tested weighing could be traceable to the density of liquid only. Due to the finance restriction in China, the liquid used for determining the volume to weight is three-distilled water. It's rigorous for the storage and usage on three-distilled water; otherwise it will affect the accuracy of density of liquid.

Fig1：Mechanical equipment

During the measurement, the hanging system under the right weighing pan is always immersed the liquid, due to the effects caused by the buoyancy and resistance from the liquid, the sensitivity of balance is changed comparing with that in air, for instance: 2 kg weight, the balance sensitivity is 20 mg and 40 mg for 20 kg in water. This is the other fact to reduce the accuracy of measurement.

The left weighing pan for the equal arm balance is used for the tare weights, and the right weighing pan is used for supporting the tested weight in air and in liquid during the measurement. Therefore, under the right weighing pan, there are a weight holder and suspension wire for hanging the tested weight when it is immersed in the liquid. According to the weighing procedure mentioned in "Volume Measurement on Weights, APMF2007 [3]", the tested weight would be measured twice. One is in air, another is in liquid. This is the third reason to reduce the accuracy of measurement that the height difference of the suspension wire between those two measurements.

Because of one layer of water bath, the temperature of liquid couldn't be controlled under the constant level and it would be changed with the temperature in the testing room. Therefore, two mercury thermometers are used in air and in liquid. Their readabilities are all 0.1℃.

The measuring procedure is similar to method A3, recommended in OIML R111 [1] (See Annex B.7.4.4). The whole measuring procedures was mentioned in paper "Volume Measurement on Weights, APMF2007 [3]" in detail.

3. ELECTRICAL EQUIPMENT

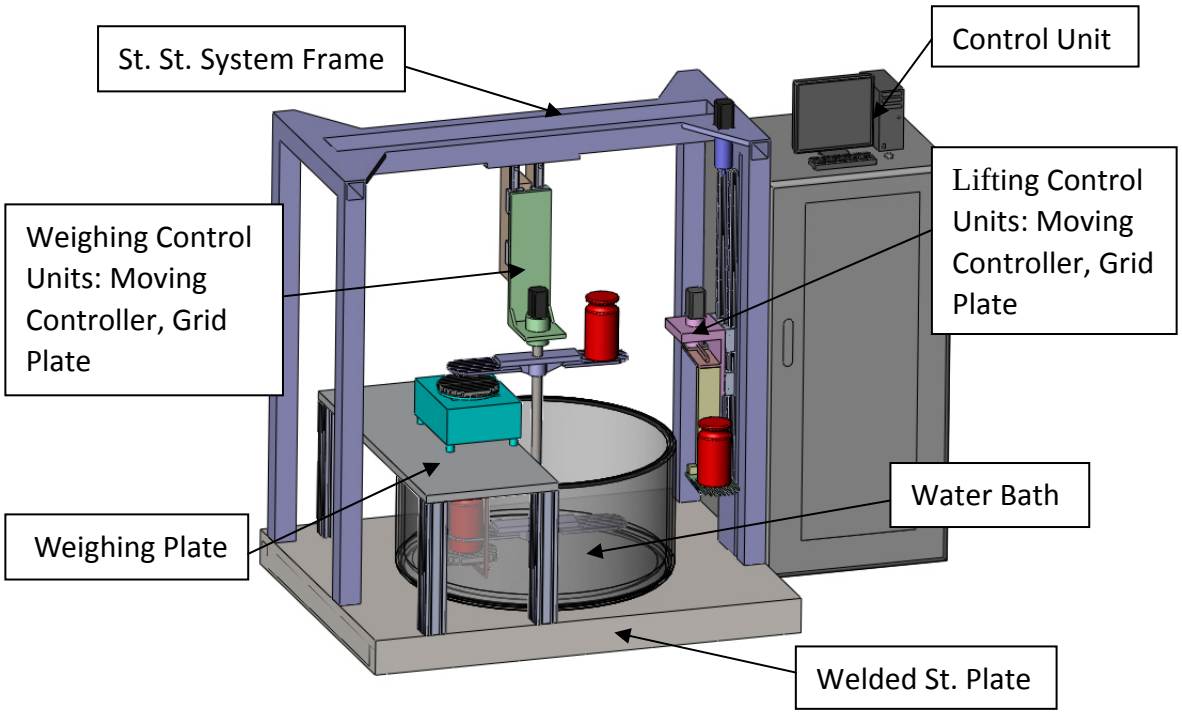


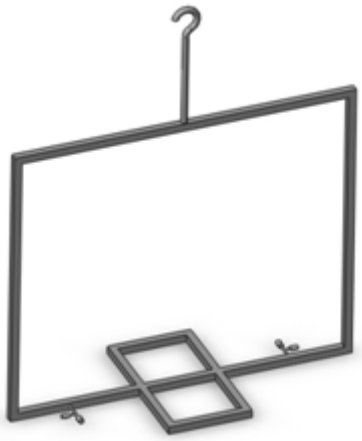
Fig2：Electrical equipment

In order to improve the accuracy of density measurement and trace the density value to the solid density, an electrical volume comparison system has been developed in NIM since 2011. Its construction is similar to VC1005 and the measuring procedures are programmed according to the method A1, recommended in OIML R111 [1].

This system includes many parts, weighing unit, whole system supports, weight moving units, weight lifting units, water bath, and system control units, see Fig2. The weighing unit for measuring 2 kg to 20 kg is an electrical balance, XP26003L. Its maximum capacity is 26 kg and readability is 1 mg. Regarding the high relative resolution (5×10^{-8}) of electrical balance and the limit space in the weighing area, a new wind shield is replaced to the old one to insure the volume measuring accuracy.

Because all mass measurements or volume comparisons should be made automatically, the original weighing pan on XP26003L has to be changed into a new one to meet the measuring procedures controlled by computer. Combined the ideas of VC1005, triangle-star weighing pan in liquid, and CC20000, big round, comb-shaped weighing pan, a new weighing pans (see Fig4) are used in air and in liquid. To support the special weighing pan in liquid, a unique frame (see Fig3) is designed to suitable the size and weight of weighing pan. The all mass of the weighing holder frame and pan in

liquid should be controlled within 6 kg because the difference between the maximum capacity and testing weight is the value.



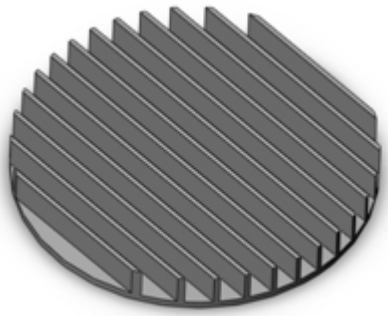


Fig3：Weighing holder frame in liquid **Fig4：Weighing pan in air and liquid**

The weight moving units are used for turning the weighing exchanger and putting weight on weighing pan in air or weighing holder in liquid. Although the design of these weighing moving units is similar with the other volume comparator in NIM, VC1005, the different point is the weighing exchanger. There are two positions on the weighing exchanger, not only in liquid, but in the air as well. These two positions are supporting the standard weight and tested weight respectively to carry out the mass comparison in air or volume comparison in liquid.

A big water bath of 1.2 m in diameter and 1 m in height could contain two pieces of 20 kg on weighing exchanger turning inside it. The thickness of water bath is about 12 mm to 15 mm. It could be strong enough to fill the distilled water and immerse the whole weights. Two platinum resistant thermometers are used to measure the temperature in air and in liquid. Their readabilities are all 0.001℃.

Due to the heavy weights 10 kg and 20 kg, would be measured, this system provides a lifting control units for taking weight(s) on the weighing position in air or in liquid. By this way, tested weight and standard weight could be put on the weighing pan to make comparison in air or in liquid easily. But a problem occurred by the lifting unit putting the weight into liquid. There is concave plate at the bottom of OIML-shaped weight. When the lifting device exchanges the weight into the weighing pan in liquid, there would be a big bubble at the bottom of weight because of the concave plate. The operator has to slope the weight smoothly to remove the bubble out of the concave plate.

To accurate the measuring result, the weighing unit, water bath, moving and lifting units are fixed on a whole welded stainless steel plate. Especially the crossbeam is used to fix the weighing moving units, including moving controller and grid plate.

The measuring procedure is similar to method A1, recommended in OIML R111 [1] (See Annex B.7.4.2). . The whole measuring procedures was mentioned in paper “Volume Measurement on Weights, APMF2007 [3]” in detail.

4. CONCLUSION

Due to complicated construction and time limit, the mechanical part of new electrical volume determination system has been completed yet. The electrical part is under production. This paper introduces the special construction of this new system. I believe the good results could be get on it after the new electrical volume comparator is completed achieved.

5. REFERENCE

1. OIML Recommendation 111《Weights of Class E1、E2、F1、F2、M1、M1-2、M2、M2-3、M3》(Ver2004E)
2. National Verification Regulation of 《Weights》, JJG99–2006
3. Volume Measurement on Weights, APMF2007