ESTABLISHMENT OF CLASS E1 MASS STANDARD OF 50 kg

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Because of the equipment limit, the dissemination of large mass has been realized by a large amount of higher class of 20 kg weights since 1950s in China. But with improvement of the technique and customer's requirements, it is necessary to establish the mass standard of 50 kg weight. In 1990s, mass standard laboratory has set up Class E1 weight sets from 20 kg to 1 mg. To extend the mass capacity up to 50 kg of Class E1, it is not only to produce Class E1 50 kg weight and import a mass comparator, but also need to lift the heavy weight from weight box to balance receptor safely.

Up to now, the mass comparator has been installed in Hepingli campus of NIM. Two pieces of Class E1 50 kg weights are determined by combination weighing method. A lifting device has been mounted close to the mass comparator in order to move the 50 kg easily.

Keywords: Mass capacity; class E1; 50 kg weight.

1. Introduction

In China, the dissemination system for mass measurement was created in 1950s. Due to the financial and technical limited, the values of large mass have to been realized by a large amount of higher class of 20 kg weights. Therefore, the mass standard weight sets are set up from 20 kg down to 1 mg not only in the provincial institutes, but in NIM as well. By this reason, the highest class of large mass, which is larger than 100 kg, is Class F₂.

Fig. 1. 50 kg mass standards in Hepingli Campus of NIM.

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H. Yao et al.

Since the time of 2000, many customers improved their equipment and required to measure 500 kg weight with Class F₁. Because there are not enough amount of Class E₂ 20 kg weights, and the mass comparator with the maximum capacity of 500 kg, there is no institute could make the dissemination for Class F₁ weights larger than 100 kg in China.

In order to solve the problem and complete NIM's CMCs, first of all, the measurement capacity of Class E₁ 50 kg should be built up. From 2010 to 2012, a project was carried out for setting up Class E₁ 50 kg mass standard. Up to now, the standard weights have been measured many times for the stability check. The mass comparator has been installed in Hepingli Campus of NIM and determined its specifications. A lifting device was also mounted to help people carry heavy weight from balance carrier to the weight container.

2. Standard Equipments

By the World Bank Loan in 1990s, NIM set up the Class E₁ non-magnetic weight sets from 20 kg to 1 mg and imported some relative accurate mass comparators. Due to the customer's requirements and technical restriction at that moment, the whole set of weight was 30 pieces. That means there was one piece of 20 kg Class E₁ weight in this set. The maximum capacity of these mass comparators was 20 kg with the readability of 0.5 mg.

The first problem for setting up Class E₁ weight of 50 kg is to purchase another Class E₁ weight of 20kg. With the original 10 kg and 20 kg of Class E₁ weights, it could make the mass comparison between 50 kg and combined weight group (20 kg+20 kg+10 kg). The second one is to import a mass comparator with the maximum capacity of 50 kg. The last one is to lift the heavy weight on the balance carrier from the weight container.

Fig. 2. Lifting crane of max capacity to 125 kg.

Fig. 3. Mass comparator-AX64004.

The 20 kg Class E₁ weight made in 1990s was non-magnetic stainless steel with the susceptibility less than 0.0006. Since the domestic production level, we finally choose the weights, 10 kg and 20 kg, made by Mettler Toledo. The other four pieces of 50 kg Class

E₁ weights were imported from Mettler Toledo at the same time. The mass comparator was AX64004 with maximum capability of 64 kg and readability of 0.1 mg. The crane was made by Demag Cranes & Components Company, Germany. It could carry the weight max to 125 kg. When the crane holds the 50 kg weight and put it on the weighing pan, the hoisting speed could decree to 0.07 m/min.

3. Technical Performance

In order to expand the mass measurement capability to Class E₁ 50 kg, the stability of mass standard from 1 kg to 50 kg should be monitored, especially the new imported weights of 10 kg, 20 kg and 50 kg from Mettler Toledo. The technical specification of mass comparator should be determined.

Table 1. Measurement uncertainty calculation on Class E₁ 50 kg.

No.	Uncertainty resources	Testing weight (50 kg)
Uncertainty from the weighing process		
1	$u_w(\overline{\Delta m}) = \frac{s(\Delta m)}{\sqrt{n}}$	0.0555 mg
Uncertainty from the reference weight		
2	$u(m_r) = \sqrt{\left(\frac{U}{k}\right)^2 + u_{inst}^2(m_r)}$	2.45 mg
Uncertainty from the air buoyancy correction		0.313 mg
3	$u_b = \sqrt{(V_{ref} - V_{test})^2 u_{\rho_a}^2 + \rho_a^2 (u_{V_{test}}^2 + u_{V_{ref}}^2) + 2 \frac{\partial m_{test}}{\partial m_{ref}} \frac{\partial m_{test}}{\partial \rho_a} u(m_{ref}, \rho_a) + 2 \frac{\partial m_{test}}{\partial m_{ref}} \frac{\partial m_{test}}{\partial V_{ref}} u(m_{ref}, V_{ref})}$	
Uncertainty from the mass comparator		
4	$u_{ba} = \sqrt{u_s^2 + u_d^2 + u_E^2}$	0.722 mg
Uncertainty due to the sensitivity of mass comparator		
4.1	$u_s = \sqrt{(\overline{\Delta m})^2 \left(\frac{u^2(m_s)}{m_s^2} + \frac{u^2(\Delta I_s)}{\Delta I_s^2} \right)}$	0.0165 μg
Uncertainty due to the display resolution of a digital mass comparator		
4.2	$u_d = \left(\frac{d}{\sqrt{3}} \right) \times \sqrt{2}$	0.0408 mg
Uncertainty due to eccentricity		
4.3	$u_E = \frac{ \Delta I_1 - \Delta I_2 }{2}$	0.710 mg
Combined standard uncertainty		
5	$u_c(m_i) = \sqrt{u_w^2(\overline{\Delta m}) + u^2(m_r) + u_b^2 + u_{ba}^2}$	2.58 mg

H. Yao et al.

The stability monitor for new 10 kg and 20 kg Class E₁ weights was started the middle of 2011 by the mass comparator CC20000 with the readability of 0.5 mg. The original weights of 10 kg and 20 kg were used to compare with the new ones by many times. The measurement uncertainties for 10 kg and 20 kg weights are better than 1.0 mg and 2.0 mg ($k=2$) respectively. After installation of AX64004, the stability of 10 kg, 20 kg and 50 kg could be carried out. Maximum mass variations are less than 0.7 mg for 10 kg, 1.5 mg for 20 kg and 2 mg for 50 kg over half year.

Mass comparator is AX64004. Its readability is 0.1 mg and maximum capacity is 64 kg. After installation, the typical repeatability could reach 0.1 mg and nominal repeatability is less than 0.3 mg. Measurement results on repeatability at night are better than those in the daytime because the temperature variation is more stable at night.

After preparation of standard weights, mass comparator and the lifting device, the measurements on Class E₁ 50 kg weight were carried out. The measuring uncertainty calculation was made based on the statement on OIML R111 “Weights of Class E₁, E₂, F₁, F₂, M₁, M₁₋₂, M₂, M₂₋₃, M₃” Edition 2004(e).

The uncertainty resources are as follows, uncertainty from the weighing process, u_w ; uncertainty from the reference weight, $u(m_r)$; uncertainty from the air buoyancy correction, u_b ; and uncertainty from the mass comparator, u_{ba} .

Measurement uncertainty calculation on Class E₁ 50 kg weight is shown in Table1. The expanded uncertainty, U , of the mass of Class E₁ 50 kg weight is as follows:

$$U(m_i) = k \times u_c(m_i) = 2 \times 2.58 \text{ mg} \approx 5.2 \text{ mg}$$

4. Conclusions

Since 2010 to 2012, the project on building up Class E₁ 50 kg standard weight was carried out by many steps. First, it's to expand the Class E₁ kilogram standard weight set from 20 kg up to 50 kg. By this step, the Class E₁ 50 kg weight could be determined the mass value from higher class of 1 kg weight by the combination weighing method. Second, it's to complete the mass capacity of NIM. The improvement of mass capacity is not only to set up the weight to 50 kg, but able to measure the relative mass as well. It's necessary to import a mass comparator. At last, to insure the safety on heavy weight and working people, a lifting device was mounted to move the weights from container to weighing pan. After all preparations, the measurements are carried out to determine the all specifications. The result could reach the requirements on Class E₁ standard weight set from 1 kg to 50 kg and it also fills the blank of NIM CMCs on 50 kg.

References

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